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INSTRUCTIONAL MEDIA--A PROCEDURE FOR THE DESIGN OF MULTIMEDIA INSTRUCTION, A CRITICAL REVIEW OF RESEARCH, AND SUGGESTIONS FOR FUTURE RESEARCH.

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A PROCEDURE WAS DEVELOPED WHEREBY EDUCATIONAL SPECIALISTS COULD PREPARE THE SPECIFICATIONS FOR MEDIA IN WHICH VARIOUS SEQUENCES OF INSTRUCTION WOULD BE PROGRAMED AND DEVELOPED. PROCEDURES WERE DEVELOPED AND TRIED FOR A SET OF BEHAVIORAL OBJECTIVES FOR AN EXPERIMENTAL CURRICULUM IN SCIENCE INSTRUCTION. IT WAS POSSIBLE TO ILLUSTRATE AND IMPLEMENT THE STEPS OUTLINED FOR SAMPLE OBJECTIVES REPRESENTING VARIOUS KINDS OF LEARNING. AN IMPLICATION OF THE STUDY WAS THAT MEDIA RESEARCH NEEDS TO BE CONDUCTED FOR SINGLE EXPERIMENTAL OBJECTIVES REPRESENTING VARIOUS KINDS OF LEARNING. (JC)

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Leslie J. Briggs
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FINAL REPORT



AMERICAN INSTITUTE FOR RESEARCH/PALO ALTO



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Leslie J. Briggs.
Project Director

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INSTRUCTIONAL MEDIA: A PROCEDURE FOR THE DESIGN OF
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CHAPTER I

The Problem and a Plan for a Solution

Leslie J. Briggs

Overview of the Problem and the Recommended Solution

The purpose of this chapter is to describe a many-faceted problem which confronts today's teachers, and to propose a solution to the problem based on a rather sweeping overhaul in the way educational materials are prepared and used.

The Problem

On the problem side, teachers are struggling with the following complex set of difficulties:

1. A great increase in the sheer number of available items of instructional material for our education courses from among which teachers must choose. There are more charts, more

workbooks, more laboratory materials -- more of everything than before in the traditional forms of presentation of instructional materials.

2. An increase in the number of new media by which instruction may be presented. Curriculum materials are now available in the form of TV, motion pictures, teaching machines, programed booklets, slides, filmstrips, and sound tapes. Thus there are on one hand, more materials presented by conventional media (books, workbooks, laboratory materials) and, on the other hand, an increasing number of items available in the form of the new media. Some of the new media, such as teaching machines and programed booklets, also confront the teacher with new concepts of how instruction should take place. Teachers sometimes have difficulty in understanding, accepting, and harmonizing these ideas with their previous views about teaching.

3. A greater need for individualized instruction in the face of growing numbers of children to be educated. The range of ability among students becomes greater under a philosophy of education for all, in which attempts are made to discourage those of lesser ability from dropping out of school. This trend, in turn, calls for even more flexible curricula to meet the needs of all kinds of students. A fixed curriculum and lock-step

methods of teaching are incompatible with achieving the multiple objectives of (a) education for all, (b) quality education, and (c) education for a rapidly changing society and new frontiers of knowledge.

4. A custom by which commercial organizations such as publishers and film makers determine what items are made available. Teachers and educational specialists can only choose from among available items the items they will use; they cannot specify the items which will be available.

5. A situation in which there is no generally understood rationale as to why some information is presented by film rather than by programmed instruction, or by books rather than by slides and sound track. All kinds of instructional objectives are presented by all kinds of media, without much rhyme or reason other than that the film maker works in his medium and the book writer works in his.

6. A result that when multiple media are used in a course of instruction, the rationale of the particular combination of media employed is no more systematic or logical than the rationale by which the component items came to be produced. There is competition among the media producers for their media to have a prominent place in the total array of items to be used, in the

absence of a theory upon which justification could exist for teaching each type of educational objective by a medium having special relevance for the kind of learning conditions required.

7. A situation in which media research has not provided the basis for development of an improved rationale upon which could be based a better way of deciding upon the media in which various materials are to be made available. Media research has not even focused upon how to choose from among existing items presented by various media. Much research has been devoted to techniques for improving films, for example, but there is a neglect of research which shows circumstances requiring that a film be made and used for instruction.

The Recommended Solution

While there are many possible approaches to solving the complex problems listed above, the approach here advocated may be outlined as follows:

1. A procedure is needed whereby educational specialists, including teachers and psychologists, prepare the specifications for the media in which various sequences of instruction will be programmed and developed.

2. The basis on which educational specialists should make these decisions should consist of a systematic way to match educational objectives with media of presentation.

3. The best available basis for the needed matching of media with objectives, in the opinion of the writer, is a rationale by which the kind of learning involved in each educational objective is stated in terms of the learning conditions required. A valuable account of the various kinds of learning, including the identification of the conditions for each, is presented¹ in the book by Gagne (1965) entitled The Conditions of Learning.

4. While one cannot directly relate classes of media with conditions of learning in such a way as to make media choices simply by comparing two tables, it is believed that the examination of the required conditions of learning for each educational objective, along with other specifiable kinds of information, can result in an improved basis for assigning the media to be used for a set of objectives. The details by which such a procedure may be applied are considered in Chapters II, III, and IV of this report, along with illustrative analyses of objectives.

5. The result of the recommended procedure, by which educational objectives are analyzed in terms of effective media of instruction, for most educational courses would be a package of multi-media instructional segments.

6. It is believed that the entire procedure is sufficiently described and illustrated in this report that several kinds of follow-on work could be carried out, including further research to improve the procedure as well as to evaluate its effectiveness.

7. The recommended procedure permits specification of media for either group instruction or for individual instruction. Consequently, the entire proposal, by which educational specialists would decide what items would be produced, is consistent with flexible curricula and individualization of instruction, in a quality educational program for all students.

8. A by-product of applying the recommended procedure for developing pre-packaged, multi-media instruction, may be the identification of needs for improved equipment to facilitate this form of instruction. Furthermore, as indicated in some of the illustrative analyses in Chapter III and in discussion in Chapter II, the type of results from the analyses is compatible with the continued development of computer-controlled instruction

and with new audiovisual control and integrating equipment which, when available, would facilitate changing from one presentation device to another rapidly. On the other hand, the analyses also indicate when very simple media are needed -- common objects and materials, printed or spoken words, or simple feedback and evaluation mechanisms such as provided by a special card or answer sheet, as Pressey has long advocated (1960).

9. The total procedure, while requiring further study in reliability among resulting judgments, and in effectiveness in improving learning, could become the technical basis for an overhaul in methods of decision-making leading to production of more effective instructional materials.

10. The end effective result of such a total system of operation in the area of materials and media of instruction is subject to test and empirical evaluation and improvement, in much the same way that programmed instructional materials are now empirically revised and evaluated. It is difficult to doubt that any appropriate procedure based on analyses of educational objectives and research in conditions of learning would result in better specification and development of relevant instructional sequences in the various media.

11. One major omission, in the procedures treated in this report, is the absence of a plan for incorporating knowledge about the individual learner into the media choices made. Eventually this step should be taken also, but it appeared necessary to restrict the present effort to procedures which should be generally effective for all students in a group. Before the recommended enlargement could be made, however, there is need for more research as to which individual variables are important for this purpose. There is also need for research to verify some of the extrapolations which must be made from laboratory findings in the application of the procedures outlined in this report. Nevertheless it may be noted that the present procedure was derived more directly from the results of laboratory research (of the sort used by Gagne in developing his treatment of The Conditions of Learning) than from classroom media research. The reasons for this are discussed in more detail in other portions of this report.

12. Finally to be noted is the practical implication of the total procedures recommended here for changes in the points in time at which educational specialists perform their functions. It is proposed that subject-matter experts, teachers, psychologists, and curriculum planners have their most important

function in specifying items to be developed by film makers, writers, and other media specialists. These educational specialists, in effect, would plan both the specification of materials and media, and the instructions to the teacher in how to handle the total multi-media package, including teacher-conducted instructional events.

In summary, the choice of the media to be employed in the classroom should take place before the items are produced, not afterwards. While such a procedure appears to reduce the local autonomy of the teacher, it is similar to the procedures employed in many experimental curriculum-development programs, in which decisions on important issues are made by a group of outstanding subject-matter experts, teachers, and psychologists. Under the proposed plan, the teacher would exercise great local autonomy in selecting the choice of units to be taken by a given child, and in evaluating his progress toward the goals of his instruction.

The Problem

Teachers today are faced with a burgeoning mass of curriculum materials and teaching aids; from among this great proliferation of books, concrete objects, charts, movies, workbooks, teaching machines, TV programs, and what not, they must somehow select the

items to be used for the instruction of their own classes. On one hand, few guidelines of general usefulness are available in the form of principles which would aid teachers in making their selections; on the other hand, there are few "packaged courses" available which would reduce the need for making such choices. Some of the choices to be made amount to decisions on what to teach; other choices involve selection of the media in which already selected content would be presented.

As new educational aids, devices, materials, and machines are introduced into the market, (the term media is employed in this report to refer to any means of presenting stimuli), the choices to be made by teachers become even more difficult to make, due both to the increase in number of items from which to choose and to the introduction of new ideas about instruction which are represented in new types of aids, such as teaching machines and programmed instruction. Many of these new ideas are difficult to understand, accept and harmonize with earlier concepts about instruction which the teachers have acquired. Some of these new ideas are threatening and anxiety-producing. Under the present system in which the teacher must make the choices, he finds himself not only confused by the mass of materials, but also lacking in dependable principles for decision-making. He also

needs supplementary training in the processes by which new media are developed, improved, and evaluated in order to arrive at sound evaluations of their relevance for the age range and educational objectives for his group of students. Where anxieties are present, his continued education may need to include use of attitude-changing techniques as well as presentation of new information and concepts about learning and teaching.

How can the teacher be aided so that he may avoid being literally overwhelmed by the problem of selecting instructional materials from among huge catalogs of available books, movies, self-instructional programs, laboratory equipment, and similar items? Such available items present themselves for consideration (via catalogs of various sorts) literally by the thousands (Hanson, 1963; Educational Media Council, 1964). To make choices more difficult, the teacher may be further confused by the arguments advanced by various specialists, each arguing the merits of TV, programmed instruction, films, or other instructional approaches.

So far, the emphasis has been placed on the difficulty of choosing the particular media items to be employed. But the teacher also faces the further difficulty of how to utilize each item, in conjunction with others, in the overall instructional

plan. If the teacher and the producer of the items both lack a rationale on how items should be selected, it follows that the method of use of the items may be equally lacking in rationale. This happenstance way of arriving at multi-media instruction is analogous to use of a shotgun rather than a rifle because the aim is poor. Surely there could be developed a better way of deciding how to use the various media.

Complicating both the media selection and the media utilization problem, teachers also face other problems which are the result of the current educational scene -- increased range of ability to be dealt with in an "education for all" milieu, the need for educational acceleration, the "knowledge explosion," the "comprehensive school." Such trends tax not only the pedagogical skills of the teacher, but also his subject-matter competency. A procedure is needed to provide more assistance to the teacher in both these areas.

The present educational scene, as sketched briefly above, contrasts sharply with the scene a couple of generations ago, when less education during a short span of schooling for fewer people was the rule. Then, a few books and other standard simple aids appeared adequate for teaching the narrower range of skills expected to result from the limited schooling provided at that time.

So far the problem has been presented from the point of view of choices among media which teachers must make under the present way by which given items of content come to be presented by the various media. The only comment which has been made concerning possible remedies through retraining of teachers has been made also in the context of existing ways of producing materials. As the discussion continues, it will be seen that the proposed solution is to change the entire basis for the production process rather than to retrain teachers in order to adjust to the present procedures.

Under present procedures, teachers and educational specialists have no effective way of influencing the decisions leading to the preparation of instructional materials in the various media, except when they serve as authors of materials or as consultants to the publisher or other developmental agency. With regard for the point that reputable developmental agencies seek the advice of teachers and other educational specialists, these latter, who are responsible for doing the educating, do not exert the same influence upon the development of instructional items that they have in their utilization.

But even if the teachers now had a greater voice in what would be taught through identification of the objectives and con-

tent to be prepared, they are without the capabilities they need to decide the media in which instruction should be programmed. In fact, media research has not provided the needed basis for matching media with objectives. It has been the purpose of this project to design a procedure which a group of specialists could employ in order to insure that good media choices are made, and that through pre-planning, effective multi-media instructional courses would be developed. Such an approach would be intended to reduce the proliferation of competing items covering the same intended objectives, with the effect that media specialists more effectively concentrate their efforts around objectives for which their respective media offer the adequate set of conditions of learning.

The desired procedure should reduce the tendency for proponents of each particular medium to apply their arts indiscriminately to all teaching objectives, in favor of concentrating upon the most relevant uses of each media.

It is the thesis of the present project that all existing media have usefulness, and that usefulness and effectiveness will be greatest when media selection is based upon a systematic analysis of the objectives of instruction. It is a further thesis that educational specialists have a rightful function in the

selection, packaging, and utilization of instructional sequences in all media.

Recommended Solution of the Problem

The purpose of this project is to outline a procedure by which teams of educational specialists would conduct analyses of course objectives for the purpose of identifying the media predicted to be most effective for each educational objective. These specifications would be stated in sufficient detail that experienced producers of educational materials in the different media (books, films, programmed instruction, slides, tapes, etc.) could proceed to develop and supply the component sequences of instruction in the media recommended by the analyses. The resulting "packages" of instruction, accompanied by a teacher's guide prepared by the educational specialists, would be available for adoption by teachers as an alternative to their having to select each item individually and then attempt to integrate them all into a course of instruction. It is suggested that such analyses might be performed by a group of educational specialists represented by master teachers, subject-matter experts, psychologists, administrators, and guidance personnel. The specifications would be developed into instructional sequences by the producers,

programers, writers, etc., who work in each medium, with review of plans and products by the group of educational specialists. Empirical tryouts and evaluations could be employed for the continued improvement of such instructional packages, by use of procedures not unlike those currently employed by the more conscientious producers of programmed instruction.

Possible Outcomes

What may be foreseen as some of the results of such a procedure as that outlined above? The following are offered as likely outcomes:

1. Development of multi-media packages of instruction which may prove to result in more effective instruction than from use of any single medium or any less systematic way of designing multi-media instruction.
2. Greater usage of individualized instruction, resulting in faster progress by most students, while retaining the values of group interaction.
3. Higher levels of attainment and more satisfactory academic progression for the majority of students.
4. More effective use of the skills of educational and production specialists.

5. More effective and creative work by the teacher with individual students.
6. Attracting more capable people into teacher-training programs.
7. Uncovering the need for new media, new techniques, and better equipment for audiovisual instruction.
8. Identification of important research problems by the very good method of trying to solve an important practical problem, and noting the points at which present knowledge is inadequate.

Why Multi-Media Instruction?

The first of the above predicted outcomes (multi-media instruction) from applying the recommended system of analysis has been selected for special comment, as it is fundamental to the type of analysis proposed.

First, it may be said that while the spoken word and the printed word are, indeed, very important forms of instructional stimuli, they are not the most effective or economical teaching stimuli for many kinds of objectives. Graphic illustrations are a feature of most textbooks, and motions and space relations are better depicted (especially for young children) by three-dimen-

sional models or motion pictures. Sounds other than speech need to be heard for many purposes -- in music, mechanics, equipment operation. Thus, other forms of audio and visual stimuli are needed to supplement written and spoken words.

Second, in addition to selecting the sensory mode to be stimulated, verbally or otherwise, it is important to note that various educational objectives represent different kinds of learning, for each of which the external conditions of learning may be quite different (Gagne, 1965; Hilgard, 1956). Gagne's treatment of this important concept forms a major aspect of the type of analysis recommended in this report.

Third, to supply the instructional events needed for each type of learning and to display instructional stimuli required in the sensory mode and quality needed, various media (audiovisual) devices are of differential effectiveness, depending upon the exact learning requirement imposed by the educational objective.

Fourth, there is sufficient knowledge (though yet very incomplete knowledge) as to the conditions required for the various kinds of learning, that this information, considered along with analysis of the instructional events and stimulus displays for each objective, can result in selection of a relevant instructional medium or media. These selections, translated

into programing specifications, can result in the means for achieving improved effectiveness in learning.

It is important to note that as crucial as is the step of identifying the type of learning required by the objective, in order to specify the external conditions of learning, this step does not of itself lead to immediate choice of the medium. Many other factors, discussed later, are taken into consideration. For example, a necessary condition may be to provide contiguity between two stimuli; but identifying the sensory mode, and type, duration, and intensity of the two stimuli is also needed. It may then be apparent that any of several media may be able to present these stimuli in the particular manner needed to satisfy the instructional event required. It is due to the variety of stimuli needed primarily in auditory and visual modes (both verbal and non-verbal), upon which the requirement for multi-media instruction is based. However for some objectives, monitoring and correcting responses are also important.

In summary, multiple media are needed primarily to provide the range of displays needed, and to provide feedback and evaluation of responses. In total, the media are the means for providing stimuli, whether the stimuli are used to motivate, to direct attention, to set a goal, to give a prompt, to evaluate, to

guide thinking, to evoke a response, or to test for transfer.

To summarize the above points, the central rationale for the proposed solution to the problem of how to choose instructional media rests on the assumption that various educational objectives require different kinds of learning. These kinds of learning, in turn, are established by different sets of conditions. The sets of conditions of learning in their turn, are made possible by the manipulation of instructional events. The way of providing or producing these instructional events is to apply appropriate stimuli. The sensory mode to be stimulated, and the detailed characteristics of the needed stimuli, together are considered in order to select the mechanisms or media to be employed to present the stimuli. Media are thus vehicles for stimulus presentation.

Examples of media include the teacher's voice, smile, or pat on the shoulder; books; charts; physical objects; pictures; sound tracks; TV; and sound-motion pictures. Such events as field trips and laboratory exercises are composed of exposure to one or more of these media for presenting stimuli. Once one specifies in detail the instructional events and the stimuli required, he is ready to choose from among several media by which the stimuli may be presented. Convenience, cost, and ease of switching from

one medium to another are considered, along with other factors, in making the choice. The final choice is made with sequencing and packaging or programing factors in mind. These will be discussed in more detail later.

Many readers will be surprised by the heavy emphasis here placed upon stimulus displays as compared to the degree of emphasis upon responses by the student. Perhaps there are three reasons for this.

First, the external conditions of learning are those imposed by the teacher and all the other stimulating media to be employed. All that the teacher or the media can supply are stimuli, whether used to motivate or to prompt out a response. In short, instruction is composed of stimuli to provide the external conditions for learning. While a particular response is often desired of the student, the media can only provide the stimuli designed to evoke the response (these may include motivating, informative, prompting, and conditioned or unconditioned stimuli). Following the response, (right, wrong, or with-held), the media can also provide feedback and evaluation. In contrast to the external conditions provided by the instruction, the student provides many internal conditions for effective learning. These may include pre-requisite skills already mastered and available as competencies to bring to the

new learning situation. They may also include certain sets which serve to focus attention and effort and to seek certain kinds of rewards. These internal conditions of learning are provided by the student; the external conditions of learning are provided by the instruction (in the form of stimuli presented by many media).

Second, while agreeing that learning is an active process on the part of the student, and that no learning takes place without activity by the learner, the most important form of activity, in the opinion of the writer, is implicit and internal. To be more specific, this view is based upon the conditions of learning required by the types of learning most heavily represented in educational objectives, especially beyond the first or second grade. Categories one through four in Gagne's analysis (1965), may require particular overt, explicitly-planned responses for learning to take place, as in learning by conditioning or shaping. But, as Gagne points out, learning of concepts, principles, and problem-solving can take place without the need to evoke particular responses from the student as an instructional event, provided that the student has access to feedback for his implicit efforts. And many of his efforts in these activities relate to recall, selection, and use of previously acquired competencies, whether in the form of a style of thinking or subordinate concepts. For these reasons,

we deal with media as ways to present stimuli, rather than as ways to evoke particular responses which it is thought are necessary to the learning of the objective.

The view of learning presented here is thus one which implies that too much emphasis often is placed on a three-component theory of learning which consists of stimulus, response, and reinforcement. This paradigm is appropriate for learning which is accurately classified as shaping of behavior, but it appears less satisfactory for concept and other learning typical of school situations for children who have already learned to read. Further discussion of this particular point of view in terms of the nature of active responding in learning has been presented elsewhere (Goldbeck and Briggs, 1962).

To summarize, media provide stimulus displays and stimuli designed to serve various instructional functions, including feedback and evaluation. Teaching machines make more frequent and explicit use of feedback than do many other media from which students learn. This use of feedback following explicitly evoked overt responses is effective for some forms of learning, but is not a necessary condition for all forms (Briggs and Angell, 1964). This kind of feedback, beyond its instructional value to the student, is often of value to the media developer in revising

materials. Many important internal conditions provided by the learner are essentially independent from the instructional stimuli provided by media, but they are important factors in achieving particularly the "higher" types of learning among the types outlined by Gagne (1965).

So far, the main justification for multi-media instruction has been stated in terms of ways to establish the various conditions of learning needed for various teaching objectives. There are at least three other possible bases for believing that multi-media instruction represents the best overall use of the individual media.

First, frequent changing of media may help prevent boredom and maintain interest and attention (Campbell, 1964).

Second, there may be individual differences among students in the relative effectiveness of various media because of the specific characteristics of the stimuli used in the various media. Using a variety of media may improve the likelihood that each child will learn, even if this requires some redundancy in the various presentations. Since redundancy (repetition of stimuli) is a condition for some types of learning, it may be well in some cases to introduce the redundancy among media presentation rather than within a sequence for one medium.

Third, short of an absolute science of learning and instruction which would guarantee a way by which each child would master the objectives to a degree set by a standard, some justification exists for a "shotgun" approach. To the extent that our choices of media are faulty, use of several media in redundancy may be to some degree justified. However, consideration of this possibility need not overshadow the main effort to select the apparently best media for presenting the type of stimuli the analysis indicates to be desirable or required.

The end result of the proposed procedure would be production of small units of instruction which are grouped in such a way as to make use of one medium for an optimal time period, based on a trade-off between very brief exposure (to avoid boredom) and very long exposure (to make for economy in production and convenience in changing from medium to medium). In general, the goal is to cluster together elements of instruction for which the same medium would be effective in providing the needed conditions of learning. Some constraints will be placed on this clustering, however, by the logical structure of the subject matter and the process by which mastery of one objective establishes a prerequisite for mastery of the next one.

Choosing Media vs. Improving Media

Why has research in educational media not already provided a procedure for the design of multi-media instruction? Apparently it is because most research has dealt with improving the techniques for developing a given medium (such as for making films) rather than with techniques for choosing media. While this research has brought sophistication in the process of developing these media, it has not in itself shown how to avoid inappropriate choices of media of presentation. Research has more often compared the effectiveness of alternate media than it has shown how to choose or use media effectively, either alone or in combinations.

A carpenter who makes good use of his tool kit does not attempt to drive nails with a saw, nor to measure levels with his brace and bit. He has been taught to use each tool for functions appropriate for it. Since it is fairly easy to specify the appropriate uses of each tool, the trained craftsman seldom uses a tool for an inappropriate purpose.

Unfortunately, the analogy of the carpenter's tool kit is more useful for stating our goal than for showing how the goal may be achieved. While the goal is to build multi-media programs of instruction, using at each step the most relevant medium, no

simple set of rules can be stated to be followed in a cookbook fashion for deciding which medium is most relevant in a given instance. It is therefore not possible to train teachers or curriculum designers by use of such simple, always applicable, maxims as "for learning concepts use a teaching machine, and for learning to solve problems use a laboratory exercise." It is equally impossible to say that mathematics should be taught by programmed instruction and science should be taught by audiovisual devices. It cannot even be said that all science concepts should be taught by any single medium. What is necessary, as will be shown in detail in this report, is to say: "Given this behavioral objective and this pre-requisite repertoire of existing skills and knowledges, this concept may be taught by the following series of instructional events, for each of which any of several media could be applicable; let us examine the matter in more detail to see which is best to select, considering cost and convenience in terms of antecedent and subsequent objectives in our instructional sequence." The proposed procedure for the design of instruction is reached by the most painstaking analysis by which a match is obtained between objectives and media.

The main goal of the work on this project, then, is to present some rationale or strategy by which a curriculum designer could,

like the carpenter, eventually succeed in choosing for each function to be performed, an acceptable and appropriate medium of instruction.

The further step to be taken is to plan to incorporate all the individual analyses of each instructional item and instructional function into convenient "packages" which permit some reasonable amount of use of the hammer before putting it aside to take up the saw. This problem of "how to change media rapidly" is crucial to the practical attainment of the goal.

Some alternate approaches to the improvement of the use of media other than by design of multi-media packages would be comparable to sharpening the tools in the kit. Continuing with the analogy, there is much prior research on how to make more effective films, or how to "program" a teaching machine so as to teach better or teach in a shorter time, to the neglect of research in how to match media to objectives.

The basis for the present decision to be concerned with the choice of media, rather than the improvement (sharpening) of a specific medium, rested partly upon the belief that present "sharpening" efforts are currently progressing more vigorously than is research in "choosing". It may also be true that from the present time onward the choice of media is in some respects a

more important question since prior research has led to sharpening.

In summary, the proposed plan of operation rests on the hypothesis that media of instruction are now often developed on whatever topics interested the developer of various media, and that media are selected for classroom use in the absence of a definite rationale for the choices made, other than reference to the catalogs of what is available. The proposed plan is to devote analytical skill in matching media with objectives in order to specify the forms in which the instructional material should be presented. Then specialists in each medium can devote their skill where it will be most effective, making better use of all media, and relieving teachers of the need to sort through so many catalogs to select material. Most important, such a procedure is believed to be a potentially important factor in achieving the present goals of education.

Other Reasons For the Proposed Approach

Better use of educational specialists. One advantage of the proposed plan for conducting analyses leading to choices of media is that educators rather than business people would decide what items are to be produced. The team of educational specialists is more likely to conduct more skillful and less biased analyses than

would either commercial producers or professional people specializing in development of a single medium. Too often a specialist in a given medium, such as programmed instruction, sets out to "program course X" when it would be better to "program components A, B, and N of course X" because programmed instruction may not be the most effective way to teach some portions of the course. This is not to say that a skillful programmer would not use excellent judgment about when to use diagrams and when to use printed words, or when to use test frames and when to use teaching frames. But some of his diagrams, perhaps, should become motion-picture sequences. On the other hand, some film makers set out to make an entire filmed course. Again, too often a film is made on a topic requiring much verbal instruction which could be taught better by a printed program which, in turn, requires responses to criterion test items, and provides confirmation and correction. While both programmed instruction and motion pictures can be used to provide skillful instruction, each contains some features the other does not -- motion and sound in the case of films, and explicit elicitation and confirmation of responses in the case of programmed instruction. The importance of this latter function depends upon the kind of learning involved, the difficulty of the material, and the ability and motivation of

the student (Lumsdaine and May, 1965).

Courses involve heterogeneous objectives. The major theme on which the proposed procedure is based is the theme that different types of educational objectives require different sets of learning conditions, and that some media would therefore more adequately supply the required learning conditions than would others. The more heterogeneous the objectives within a given course of instruction, then, the more likely it would be that multiple media are needed, because a variety of forms of stimuli is required. The basis for this particular point in the argument is that various objectives require the student to make use of spoken words, written words, pictures, objects, sounds, movement-produced stimuli, etc. While there may be several acceptable ways to provide each type of stimuli, providing them all would normally require several media. Furthermore, presentation of subject matter must be coupled with other instructional events, such as prompting, setting the goal, guiding thinking, and providing evaluation.

Individual differences. Individual differences in rate of learning are marked, although the reasons for the different rates are difficult to identify. It is therefore difficult to know which variables in instruction other than rate of presentation

need be modified for certain individuals. One view is that the same media program can be used for all students by simply permitting the student to proceed at his own rate. An alternate view is that there are qualitative differences among students in their "learning styles", so that different kinds of stimuli are needed by different learners. More evidence is needed as to the most important respects in which instructional procedures need to be adapted to the individual learner.

In the judgment of the writer, more is known about how learning conditions should be varied among types of learning objectives (as outlined by Gagne, 1965) than is known about how instruction should be varied among individuals for a given type of learning. Therefore the procedures recommended here are based on the former rather than the latter kinds of variation. A recommended area for further research is the study of how the optimum instructional conditions may vary among individuals for specific kinds of learning.

In spite of the above complexities, it appears safe to hazard the guess that one reason why individuals differ in rate of learning is because they possess different sets of competencies -- e.g., some students possess the pre-requisite skills needed for the new learning and some do not. Therefore use of pre-tests over pre-

requisite skills and knowledges, and remedial instruction in the deficiencies, would be one approach in adjusting to individual differences.

Use of branching procedures, as by computer-controlled instruction, consists of selecting the stimuli to be presented upon the basis of how well the student does from point to point during the instruction. Thus if a student understands a prerequisite concept, the next stimulus may be a verbal statement. If the student does not know the concept, it may have to be taught by a motion picture sequence before the verbal statement is presented. Hence the requirement for different forms of stimuli, presented possibly by different media. Prior research has helped identify some of the differential conditions under which words and pictures are effective stimuli (Lumsdaine and May, 1965), and these conditions pertain more directly to differences in the nature of what is to be learned than to differences among learners in the form of the effective stimuli.

In summary, beyond the appraisal of the learner's prior skills and knowledge, and helping the learner find his optimum rate of exposure to the materials, the writer is not prepared to state other ways in which instruction in required objectives should be adapted to the individual. Of course the best choice

of objectives for the individual is a separate matter. But for even this limited set of reasons, individualization of instruction is desirable, both as to goals to be selected and rates of progress in learning.

The possibility is recognized that eventually further research, may uncover sufficient information concerning individual differences in learning that a computer could arrange "branching" in functions and media other than those suggested here. At least the present procedure for identifying media could well be expanded later to utilize such new research findings.

The general need for individualized instruction requires considerable use of types of media which are "self-contained" -- e.g., those which do not require the teacher's presence at all times. Therefore media which have built-in appraisal and feedback (such as teaching machines) are needed more clearly for individualized instruction than for group instruction. Thus one reason for choosing between alternate media, even when the type of stimulus to be presented is a constant, is to meet the differing procedural requirements of individual and group instruction.

Recommendations of previous writers. Previous writers of reviews of the literature, as well as those reporting empirical findings, have made statements which generally support some of the

rationale underlying the present discussion concerning the need for procedures for designing multi-media instruction. Although a separate chapter of this report is devoted to a review of media literature, some selected items are presented here.

Allen (1959), after presenting results of his review of research on new educational media, calls for (a) the discovery of unique educational characteristics of each medium which would lead to better selection of media for specific teaching objectives, (b) determination of the effects of multi-media instruction over prolonged periods for various types of learners and subject matters, (c) establishment of relationships between learner characteristics and learning from new media, and (d) analysis of the effects of complete "packages" of media designed to teach a single concept. In a separate report, this same author (Allen, 1952) presents evidence that multi-media instruction can lead to greater learning than that from a single medium. This general finding is supported also by Bryan (1961).

Carpenter (1960), commenting upon research findings from the use of educational TV, pointed to the need to work on the problem of defining the specific teaching-learning functions, and to the need for a taxonomy of learning and research concerning requirements for different kinds of specific learning.

McBeath (1961) raises an interesting additional possible source of interaction of individual characteristics with media, in his finding that boys and girls profit differently from some media. Moldstad (1964), reviewing studies in instructional media, refers to investigator Hugh McKeegan's hypothesis that a more efficient method (than those investigated) might involve a combination of programmed material, case studies, and planned class discussions. The function of the latter, following Gagne's (1965) reasoning, presumably would especially be to promote transfer. A project reported by Muller (1965) consists of making a range of media equipment and materials available in each classroom in several school systems. Schramm and Oberholtzer (1964) report superior results for multi-media instruction in Spanish. Schwarzwaldner (1960) reported that in most instances studied, TV served to facilitate the effectiveness of teachers' efforts. Klaus and Lumsdaine (1960), and Goldbeck et al. (1962), found that programmed instruction combined with teacher-led instruction was superior to teacher-led instruction alone. Several other instances in which combined media were found superior to single media are reported by Lumsdaine and May (1965). There exist, then, both theoretical and empirical support for the use of multi-media instruction even when it was not designed by use of the kind of

systematic procedure here recommended. It is at least consistent with these findings to suppose that the procedure presently recommended, if vigorously applied in development of multi-media instruction, could result in even greater improvements than those previously reported.

Equipment Implications

While the kind of analysis of media requirements being recommended can result in effective utilization of presently-available projectors, teaching machines, and other equipment, a by-product of the analyses could be the identification of needed new equipment, materials, and formats for effective stimulus displays.

Once the kinds of stimuli are identified to fulfill the requirements of the necessary instructional events, the mechanism by which the stimuli will be presented can be chosen. The final choice, as shown in more detail later, rests on the capability of the medium selected to stimulate the chosen sensory mode with the kind of stimuli specified, in the intensity, duration, and sequence required. Other factors in the choice are economy and convenience, when viewed in terms of arrangements for entire sequences of instruction.

The need for frequent changes in media is anticipated, to prevent boredom, to provide the most appropriate medium for each

instructional event, and to sequence elements of instruction in such an order that pre-requisite component or simple skills and concepts are established before introduction of more complex learning. Analyses of the total objectives of a course often make possible their arrangement in a definite hierarchical order (Gagne and Paradise, 1961), or at least in a logical order, so that one sequence builds effectively upon previous ones.

When options in sequencing of instructional elements are evident, the sequencing may then be a matter of the convenience and economy brought about by using one medium for a reasonably long period.

If the best sequencing requires very frequent switching from one equipment to another to obtain the required stimulus presentations, present-day equipment will often be found cumbersome and awkward to handle, especially for individualized instruction. Requirements for such rapid switching, for either group instruction or individual instruction, represents identification of the need for improved audiovisual and other devices. Some of the needed new devices may be independent pieces of gear, like a magazine-loaded motion-picture film projector, or a random-access slide projector. On the other hand, need is anticipated for integrating and control mechanisms, consisting of a way to

program and activate several devices for presenting sound and video displays.

New kinds of such equipment might make use of some of the following functions: (a) rapid alternation capability for audio and video presentations, (b) rapid random-access capability, (c) integration of stimulus, response, and feedback features, and (d) computer-controlled branching of many sorts. Available now are master control devices which trigger the functions of one or more projectors and recorders, and permit instructor over-ride or interruption of pre-programed presentations when cumulative error responses of a group of students signal a need for modification of the program. Such equipment capabilities, further refined and tied in with computer control, represent the kind of device referred to here as a way to implement individualized, multi-media instruction in the future. In the meantime, separate (though awkward to handle) components of multi-media instruction, if available, could be used as a testing ground to help further specify the function needed in more sophisticated equipment. As said before, much more research is also needed as to the kind of data about the individual learner which should be fed into the computer.

While awaiting new equipment advances, sequencing of instruction may be done so as to group together those elements of

instruction requiring the same set of learning conditions, at least when such latitude of sequencing is not precluded by other consideration, such as the logical structure of the material.

In Chapter III, an illustration is presented of how the analysis of the media requirements can be implemented either with or without complex audiovisual equipment, and by either individual or group procedures. Thus it is seen that adoption of the method of analysis can result in either pre-packaged multi-media instruction, or in teacher-conducted instruction in which the relevant materials and directions for use are provided by the developers of the curriculum. The method of analysis is thus useful for conventional instruction or for utilization of advanced instructional equipment. When local option or economy requires teacher-conducted instruction, the instruction can still benefit from the analysis by educational specialists.

It is the above feature of the method of analysis which should make it equally acceptable to those who are strongly in favor of simple and inexpensive methods applied in group instruction by the teacher, and to those who can afford to utilize highly automated and highly individualized instruction which may involve computers and master control-and-presentation devices. It is

apparent that the present writer believes that the best and most efficient instruction ultimately will be attained by the latter, more elaborate alternative. Nevertheless, there is no intent here to deny the values of socialization, group interaction, and the economy of simple media.

The educational system of the distant future will presumably utilize individual study stations served by computers and audio-visual devices, with highly individualized instructional units provided by branching procedures (Coulson, 1962). The teacher will help select the program the child will follow, will employ group motivation and learning procedures integrated with individual study, and will provide evaluation and guidance.

In the meantime, evaluation of the system of analysis can proceed with the simpler, if more awkward, but economical, available means for presenting the stimulus displays required by the analysis.

Procedures

At the outset of the project it was anticipated that the desired procedures of analysis to be developed during the course of the project would not rely directly or heavily upon the existing media research literature. One reason leading to this expectation

was the focus upon the distinction, often stressed in this report, between identification of variables which lead to making a given medium effective, and methods for selecting the most appropriate medium. Nevertheless, it was planned from the beginning that a selective review of several types of literature would be made in order to search for the most relevant information which did exist. The types of literature reviewed and the degree of relevance resulting are summarized next.

It was thought to be at least a possibility, at the beginning of the project, that of the total media research literature there might be a reasonably large number of reports of experiments which employed a homogeneous set of instructional content which could be identified as representing a particular type of learning, such as the types outlined by Gagne (1965). However, there were not found a sufficient number of such experiments for a sufficient variety of types of learning to make the reports useful for the present purpose. Some of the best experiments, employing well-defined tasks which could be categorized as to the type of learning involved, had been conducted for special military purposes, such as in how to tie knots, and were thus not of broad relevance to educational objectives. Many of this kind of study were recently reviewed by Travers (1964). Thus, an initial

screening of some 2,000 titles in audiovisual research made it apparent that there had been reported relatively little research having the characteristics mentioned above. In fact, reviews of classroom research in educational media usually were concluded by statements that more analytic research is needed in order to reach conclusions.

There appear to be several reasons why the classroom research literature did not provide the ingredients for the method of analysis outlined in this report. Many experiments were designed to compare the overall effects of one medium with another, or with a combination of media, over an entire course. While such experiments are of value for the practical purpose of choosing among existing packages of instruction on particular topics, they do not represent a basis for designing an analytic procedure for planning new instructional courses. When a lengthy course or sequence, representing several kinds of learning, is prepared in two different media and the results analyzed, the most frequent result is a failure to demonstrate a significant difference. One reason for such a finding could be that each of the media compared was more effective for some elements of instruction and less effective for other elements, so that the differences in effectiveness among media were canceled out in the overall analysis.

Other reasons for the failure of such experiments to demonstrate significant differences among media have been outlined by Lumsdaine and May (1965).

Another problem in employing the classroom literature for the present purposes was the failure to describe the content of instruction in sufficient detail that the type of learning involved could be identified. When it is suspected that the materials used in an experiment did involve several types of learning, it would be necessary, for the present purpose, to be able to identify specific criterion test items which correspond to the separate types of learning presented during the experiment. Almost no investigators report data which make this kind of analysis possible. Due to the limited time period for this project, and to the lack of the above kinds of information, few conclusions of an analytic nature could be drawn from the classroom research literature.

Another complicating factor limiting the value of prior classroom research is the difficulty of distinguishing the effects of the choice of the media from the skill with which the media were programed for the learning objectives involved. It was thus often impossible to determine whether a given result was due to (a) the choice of the media, (b) skillfulness of the programing

of the media, or (c) good integration of the various media in a composite method of teaching. Furthermore, if it may be assumed that in those experiments there was sometimes inappropriate use of media for the learning objective at hand, it would then not be desirable to employ the findings from those experiments in attempting to develop an improved method for making more appropriate media choices.

As a result of the above difficulties, the findings from classroom media research could be used directly only in that they provided some evidence supporting the present arguments in favor of multi-media instruction over single-medium instruction. For this reason the chapter in this report on the review of classroom media research appears later than otherwise might have been the case, as this review did not provide the basic structure of the approach for the method of analysis here recommended. Even so, it was judged worthwhile, in terms of project objectives, to review a reasonably large number of reports falling under one or more of the following categories: (a) comparative effectiveness studies, (b) utilization studies, and (c) basic studies. Definitions of the characteristics of these categories of studies are given in Chapter V.

The next step in the work of the project was to consider other kinds of literature which might be helpful. A number of theoretical and laboratory reports were reviewed, as were sources dealing with taxonomies of educational objectives and taxonomies of learning conditions. Also, various reviews of the literature were carefully considered. Perhaps the most frequent reference during the course of the work on the project was made to the following sources: Bloom, et al. (1956); Schramm (¹⁹⁶⁴~~1960~~); Travers (1964); Allen (1960); May and Lumsdaine (1958); Lumsdaine and May (1965); and Gagne (1965). As has been shown earlier, the book by Gagne was found to be the most directly useful for two reasons: (a) it contained a review of laboratory investigations which represent an almost completely different literature than the classroom experiments previously reviewed during the project, and (b) the results and conclusions from the review made by Gagne were organized in accordance with the eight types of learning he identifies, and each type of learning is discussed in terms of relevant instructional events. While Gagne's book does not address itself explicitly to the idea of choice of media, at least not in the context discussed here, it does systematically consider the capabilities of various media to supply various instructional events. For these reasons this source was drawn on more directly

and more heavily than any other source in the further development of work under this project.

At this point in the project it was recognized that an overall, generally usable, step-by-step procedure was needed which would provide a way for systematically relating the following matters: (a) educational objectives, stated in terms of both the nature of the required criterion performance, and in terms of the subject matter with respect to which the performance is oriented, (b) a classification of educational objectives as to type of learning required, (c) a way to consider the relevant conditions of learning for the type of learning involved in the light of the kind of stimuli required to constitute appropriate instructional events, (d) a way for further considering the conditions of learning, their associated instructional events, and the required stimuli in order to translate the stimuli in terms of possible media of presentation, (e) a way to reach a decision on media choices when several media of presentation appear equally relevant -- with consideration of the factors of economy, sequencing, and convenience in use. The overall packaging of the total course, it was recognized, should permit an option between use of either conventional methods and existing media, or either individualized or group-conducted multi-media instruction, employing sophisticated equipment.

Such a comprehensive procedure, it was next thought, would be best developed by trying out actual analyses with some sample sets of educational objectives. It was immediately discovered that some educational objectives are stated in behavioral terms and some are stated in content terms. It was consequently of interest to determine whether the same general strategy for analysis could be applied under both of these circumstances. Chapter III presents a sample analysis for a course in which the objectives were initially stated in behavioral terms, and Chapter IV presents a sample analysis for a course in which the objectives were initially stated in subject-matter terms. While the former case is easier to handle by the method of analysis outlined in Chapter II, it appears possible, as shown in Chapter IV, to then restate content objectives so that the same analysis will apply. In fact, as shown later, the preferred form of stating objectives for the type of analysis proposed, includes both a behavioral and a subject-matter component.

In the course of the development of the analyses presented in Chapters III and IV, many alternate ways of developing the procedure for choosing media were discussed, or perhaps it should be said, were debated. While it is not the purpose here to defend any specific series of steps by which media are matched with

objectives, it is the purpose of this report to present two or more possible ways of proceeding.

As a result of the role of the trial analyses in the total procedures employed in the project, the sequence of steps described in Chapter II was developed in piece-meal fashion as certain problems were encountered and resolved during the course of the trial analyses. It might be said, then, that the day-by-day procedure represented alternation between efforts to outline the procedure in general, and efforts to apply variations of the procedure in trial analyses. At one point during this analysis period, the consultative assistance provided by Gagne enabled the writer to settle upon the general work steps and procedure as presented in Chapter II.

While it is felt that the steps outlined in Chapter II are generally those ultimately desired, it is anticipated that further trial analyses and other follow-on work to this project may well reveal improvements in the details of the procedure.

Further development and evaluation of the overall series of steps could involve many kinds of follow-on research which are discussed in Chapter VI.

CHAPTER II

A Procedure for Choosing Media for Instruction

Leslie J. Briggs, Robert M. Gagne, and Mark A. May

Introduction

In this chapter, the recommended procedure for choosing instructional media is presented in three degrees of detail. First, the various steps in the procedure are simply listed in brief outline form to provide a first overview of the total procedure. Second, a general account is given of how the steps are followed through for the six forms of learning thought to be required most frequently in educational courses. Third, a detailed discussion of each step is presented to show more fully the significance of each step in reaching the media decisions.

The Steps in the Procedure

1. State the behavioral objectives for the course or unit of instruction in the sequence in which they should be taught.
2. For each objective, identify the type of learning involved.

3. Using the required conditions of learning as a guide, design a "media program" for each objective which lists the instructional events, identifies the characteristics of required stimuli, and states the media options which would be acceptable.
4. Prepare a summary of the media options for a group of objectives making up a sequence of instruction, and scan these to identify frequently occurring media options.
5. Assign the media in which the instruction should be packaged to achieve the best trade-off in respect to effective stimulus display, convenience in changing from medium to medium, and economy in terms of size of unit in which each sequence is to be prepared in the given media.
6. Write specifications for the preparation of the instruction by the various media producers.

A General Account of the Procedure

For purposes of this description, media refers to any and all physical means of representing the entire set of stimulus conditions required in the instruction of a learner. Thus media include, as important and often-used varieties, arrangements for printed communication (such as printed pages) and for oral communication (such as a teacher). Also included are actual objects

(rocks, leaves, manufactured products, etc.) when these can be directly observed by the learner, and special devices and materials, such as films, teaching machines, and workbooks.

It is assumed that what is being designed is a course of instruction (like geography, American history, plane geometry), or at least a substantial portion of a course, such as "trade winds of the earth," or "origins of the American Revolution." The designer proceeds to do this, however, in a topic-by-topic fashion, where each topic may be considered to reflect a unitary course objective.

The general rationale is this: When stated in terms of human performance, objectives imply a requirement for certain types of learning. Occasionally, these types are as simple as verbal associates, simple motor chains, and multiple discriminations. Much more frequently they are concepts, principles, and problem solving. Each type of learning requires its own external conditions of learning. These conditions, which may be conceived as a sequence of events in instruction, are in turn established by stimuli presented by various media. Each of the events (or steps) in this sequence may be accomplished by more than one medium. Accordingly, the most basic choices of media are made at this detailed level of analysis of the instructional process.

When the designer makes these choices, he is in a sense "programing" the conditions for learning each objective of the course or course segment.

When the "media programs" are examined for an entire set of objectives contained in a course segment, one can make a determination of the kind of medium which might be desirable, in terms of economy or other criteria, to use for the presentation of the course segment. Thus, if several objectives in a row require the use of pictures, it may be desirable to design a film, film strip, or a set of slides for this particular portion of the course. The advantage of the procedure outlined lies mainly in the fact that it permits a determination of the applicability and desirability of one or another medium in portions of the course that may in turn be only part of a course segment. It permits the identification of what these portions are which would profit from the use of particular media, as well as where they fit into the course as a whole.

Step 1.

This is the description of the course segment in terms of "behavioral objectives," which means simply stating the performance to be expected of the student at the end of instruction.

The advantages of such description are mainly two: (a) the

statement is unambiguous (or, in a sense, reliable in that two observers of the performance would agree on it), and (b) the statement carries a clear implication of the capability to be acquired (whether concept, rule, or whatever) and therefore identifies the conditions of learning involved (as determined by reference to particular research findings or to a summary of conditions as presented by Gagne, 1965).

Step 2.

Identifying the type of learning involved. As previously stated, the most frequently occurring types of learning in school subjects are concept learning, principle learning (including "fact learning"), and problem solving. It should be remembered, however, that simpler forms of learning do occur in school subjects. For example, memorization of short or long verbal sequences may be required. Simple motor chains may occur in such activities as pronouncing the sounds of foreign words (or English words, for a young child), or in children's printing or writing. Multiple discriminations may have to be established, for example, in distinguishing squares, rectangles, triangles, or in distinguishing printed letters.

The problem of what shall be called a "concept" is worthy of mention. The most basic kinds of concepts are "concepts by discrimination," which require the presentation of a suitable variety of stimuli, either in actual or pictorial form, as a part of the learning conditions. Triangle is an example. Other "concepts" are, however, learned by means of verbal media of instruction. These might be called "concepts by definition," and an example is the concept of universal gravitation. In terms of Gagne's conditions of learning, these are the same as principles.

It may also be noted that the learning conditions necessary to establish principles are subject to variation in what has been called "amount of guidance." When this amount is small, the conditions are usually said to characterize "learning by discovery." When the amount is extensive, one sometimes speaks of "didactic instruction." Actually, these two sets of conditions do not differ as much as most people seem to think. At any rate the evidence that one method is superior is scanty.

Step 3.

Designing a "media program" or "media schedule." In taking this step, one needs to describe the sequence of events that

represents the learning conditions required for each form of learning determined in Step 2. It is noteworthy that certain conditions are common to all varieties of learning (for example, presenting the stimulus, directing attention, appraising), whereas others are peculiar to particular types.

Chaining

<u>Instructional Event</u>	<u>Medium</u>
(1) Presenting cue stimuli in sequence.	Practice with actual equipment. (Note that we are dealing here with response-generated as well as external cues.)
(2) Appraisal.	

Verbal Association

<u>Instructional Event</u>	<u>Medium</u>
(1) Presenting cue stimuli in sequence.	Practice with oral or printed verbal units presented in sequence (See note above).
(2) Confirmation of responses.	Oral or printed verbal units.
(3) Appraisal.	Oral or printed verbal units.

Multiple Discrimination

<u>Instructional Event</u>	<u>Medium</u>
(1) Presentation of individual stimuli one by one.	Actual object or pictures.
(2) Progressive part practice.	Actual object or pictures.
(3) Confirmation.	Actual object or pictures.
(4) Appraisal.	

Concept

<u>Instructional Event</u>	<u>Medium</u>
(1) Presenting the stimulus examples.	Actual objects or pictures.
(2) Stimulating recall of individual (specific) links, usually verbal.	Oral or printed word.
(3) Appraisal.	Actual objects or pictures.

Principle

<u>Instructional Event</u>	<u>Medium</u>
(1) Inform learner about performance required.	May require objects or pictures (depending upon objective).
(2) Stimulating recall of component concepts.	May be done by oral or printed speech; actual objects or pictures may be desirable (depending upon objective).
(3) Verbal cueing.	Oral or printed words.
(4) Appraisal.	May require objects or pictures (depending upon objective).

Problem Solving

<u>Instructional Event</u>	<u>Medium</u>
(1) Inform learner about performance required.	May require objects or pictures (depending upon objectives).
(2) Stimulating recall of component concepts.	May be done by oral or printed speech; actual objects or pictures may be desirable (depending on objective).
(3) Verbal guidance.	Oral or printed words.
(4) Appraisal.	May require objects or pictures (depending upon objectives).

Step 4.

Having made the analysis described previously for each single objective, one then needs to look at the course or course segment in some total sense. This might be done by making a table to facilitate review of the individual media options stated for the individual objectives in order to identify the best medium for some reasonably sized unit of instruction.

Step 5.

Determining appropriateness of media for portions of the course is the next step. This is a complex decision which cannot be done

in cookbook fashion. For example, if the introductory portion of a course in science requires the learning of a number of concepts, as well as the application of principles involving these concepts, the need for pictures (or actual objects) may be frequent. In such a case, an instructional sequence emphasizing pictures might be an efficient way to present this part of the course. In practice, a sequence of slides or a film might be designed, and might be the medium of choice provided it could include the other modes of presentation required (accompanying oral and printed speech).

At the other end of the spectrum, there will be portions of a course which need pictures to only a limited degree. For example, if the student already knows the required concepts, a presentation of the principles related to the "powers of the Presidency" is simply not going to be helped by many pictures, if any. The reason is that the objective, stated as "State the limitations of the powers of the President, as defined by the Constitution", implies the learning of principles in which each instructional event is accomplished by presentation of oral or printed speech.

When a series of analyses of objectives indicates need for a mixture of diagrams, still pictures, verbal descriptions, and decisions to be made by the student after studying these elements, a format like programmed instruction would be appropriate.

If movements of objects in space and time relationships are involved, as in understanding what causes night and day, a motion picture showing rotation of the earth and its revolution about the sun, accompanied by sound narration of the principles involved, would be relevant.

Further Discussion of the Steps in the Procedure

Stating the Objectives

This is the description of the course segment in terms of "behavioral objectives," which means stating the performance to be expected of the student at the end of the instruction. Two advantages of such description have been previously stated: (a) the statement is unambiguous, and it indicates how the student's learning could be evaluated; and (b) the statement carries the basic information needed to identify the required conditions of learning. A third advantage of the behavioral objectives is that they represent a convenient way to consider and determine the sequence in which the objectives should be taken up in the instruction.

Structure of the course. For some courses, the objectives may be arranged in a pyramid type of structure, as in the analysis of mathematics instruction by Gagne and Paradise (1961). In such a

structure, "layers" of competencies are identified. Options exist within layers as to sequence of acquisition, but acquisition of one layer in its entirety is called for before presentation of the next higher (or more complex) layer.

Campbell (1962) has reported a mathematical-empirical procedure for obtaining an index of dependency among test items covering the objectives of instruction. The index of dependence-independence reflects the extent to which passing or failing one item is related to passing or failing another. This index reflects abilities related to the items, and differences in ability among learners. The results of the computations are used to determine whether by-passing (branching) or fixed linear sequences of instruction are indicated. The index also reflects, among other things, the extent to which the objectives appear to represent a hierarchy or a flat structure. It is only when objectives are stated in terms of competency (performance) that the structure of the learning has much meaning in the design of instruction. Elements of subject matter might be arranged in a "logical" order in the opinion of some person, but the arrangement would have no particular empirical basis as concerns the process of learning, until the subject-matter elements are related to behavioral elements.

While research on the structure of courses in terms of the necessary learning sequences is meager, the two studies mentioned above at least suggest that some courses represent "hierarchies" of skills, but others may be "linear" or "flat" in structure, so that great latitude would exist for many ways of sequencing. Such a degree of latitude in sequencing often would make media choices easier to arrange for the size of segment which is economical and convenient, and thus fewer compromises from the "media program" would be made necessary. In both hierarchical and flat structures there may be many options possible in the sequencing of the objectives for the course. Whether some courses represent structures other than these two kinds appears uncertain.

At any rate, one reason for arranging objectives in a sequence of some sort at the outset is to consider the extent to which learning of one may facilitate learning of another, or may at least have a bearing upon the media to be used in each case. Another reason is that, even if objectives in a series transfer heavily, one to the next (e.g., they have a high dependency index), whichever objective comes first needs to be examined in terms of assumed prior knowledge at the start of the formal instruction. Pre-tests of pre-requisites probably need to be more extensive for independent objectives than for inter-dependent objectives.

The nature of behavioral objectives. In a sense, behavioral objectives, stated for the small units of instruction referred to here, often do have both a "behavioral" and a "content" element. In contrast to a behavioral objective, however, a statement like "Learn about the radius of a circle" is not a behavioral objective at all, as it does not imply either what the student must be able to do after the instruction (or how he would be tested), nor does it say anything about the instruction needed concerning the concept of radius. But there are a number of behavioral statements which could be made for this element of instruction. Some alternatives the course designer could consider, possibly finally choosing more than one, are as follows:

1. Given several drawings of circles, some containing radii, some diameters, and some tangent lines, the student must be able to point correctly to all the radii.
2. The student must give a verbal definition of the radius of a circle.
3. The student must respond correctly to the request "Draw a circle and its radius."
4. The student must be able to state a formula showing the relation of the radius to the area of a circle.
5. The student must be able to solve problems in area, with the radius given.

Perhaps teachers would say that a student must be able to do all the above things to show he "really understands" the concept of radius. But the point is that instruction could be designed (including identification of the media to be employed) and tests could be developed on the basis of any or all of the numbered statements, but not upon the basis of "learning about the radius of the circle" (see Mager, 1962, for a further expansion of this topic).

The numbered statements are of value, primarily, because they are stated in behavioral terms for a small unit of instruction. Admittedly, they involve subject-matter content because they deal with "radius" and "circle," but the nature of the instructional content, and hence the conditions of learning needed, hinge around the behavioral distinctions. For example, statement No. 1 could be taught by discrimination training in which the teacher points to circles and their lines and says "radius" or "not a radius," and the student could learn by watching. But for statement No. 2, the conditions for verbal association, or chaining, must be established, primarily by repetition. Performing statement No. 5 would require use of concepts and principles to solve problems, a much more complex and lengthy instructional procedure.

It may be now agreed that educational objectives are usually stated in much more general terms. The generality of the terms

acceptable hinges upon the purpose for stating objectives. For purposes of deciding upon the general scope for a liberal arts college, it may be necessary only to list the instructional departments or courses which will be included. For purposes of identifying the primary nature of a high school, it may be called "vocational," "college preparatory," or "comprehensive." But for designing instruction with respect to the best use of media of instruction, much more specificity is needed in both the behavioral and the content components of the statements of objectives.

For those who find it difficult to write behavioral objectives, as for beginning students in programmed instruction workshops, one practice in use is to have the students write the "criterion frames" for a programmed sequence before they concern themselves with "teaching frames." Others find it helpful to think in terms of "what the student must do, upon what command, with what givens, with what result, to what standard of acceptance."

Stated differently, it may be said that acceptable statements of objectives for present purposes contain two principal elements: do (point to), and what (the circle that shows a radius). These may be labeled the behavioral and the content elements of the statement of the objective. In some cases at least, the statement also should indicate the acceptable standard -- cases in which

performance other than all correct or all wrong may be anticipated, or cases in which time limits should be set.

But as to the making of statements of objectives which separate the kind of performance from the subject-matter referent, this would be a step away from, rather than a step toward, defining instructional conditions and the relevant media. Any separate list of either type of element (e.g., area of a circle, diameter of a cylinder, the verbs in sentences, on one hand, and say, do, compute, state, explain, on the other hand) may conceivably be useful for some purposes, but not for the purpose of this project. (Special cases may consist of one action word and several content words, such as "be able to spell the following list of words," or perhaps the opposite case of doing several kinds of manipulations, using a single concept.)

To round out this phase of the discussion, consideration may be given to the familiar objective of "learning for its own sake" rather than for some utilitarian, performance purpose. Upon closer examination, two comments may be relevant: (a) one might not wish to go through the type of analysis here being considered if there are no objectives other than learning subject matter for its own sake; and (b) probably behavioral objectives could be stated in place of "learning for the sake of learning," even if only in terms of such general criteria as "learning generalizable study habits useful in

later learning," "learning to use a library," "learning to like music," and "wanting to read more Shakespeare." For objectives closely relating to enjoyment rather than to more specific performance capabilities, probably some important conditions are to "let the student stop studying when he wants to," "make interest first and specific learning objectives secondary," "don't require the course," and other such conditions which, as desirable as they may be from a "learning for enjoyment" point of view, might at times conflict with learning conditions for basic skills needed by all children.

While the global statements of educational goals may be useful for policy and general educational planning purposes, goals like "good citizenship," "moral conduct," "vocational competency," and "appreciation of cultural values" have to be broken down into much more detailed form for the purpose of pre-planning of instructional packages. Even goals stated in different general yet skill-oriented terms, such as "command of the language," "ability to communicate," "athletic competency," and "human relations" are not the terms in which the details of instruction can be planned.

A final, explicit reason for not employing subject-matter classifications which are separate from behavioral statements for the present purpose is that they do not alone represent a step

closer to specification of media. That is, a concept in economics is not necessarily any more different from a concept in physics than are two concepts in economics or two concepts in physics, in terms of the instructional media needed. The general conditions for learning of all concepts are the same, except for the distinction previously made between those learned by discrimination and those learned as verbal statements. The media for instruction, however, must be considered separately for each particular concept to be taught, regardless of their belonging together in a particular course. At least that is the conclusion which has been reached during the course of work on this project.

The basis for evaluation. One reason for stating objectives in behavioral terms, of course, is to furnish a basis for deciding when objectives have been met. In other words, the behavioral objective clearly implies the kind of test question or exercise which would be administered to determine that the instruction was successful for that objective. For many objectives, the relevant test is a test which involves "transfer." That is, if the concept "triangle" has been taught by use of wooden objects, strings, and wires which are of this particular shape, other materials and objects would be used for a test to be sure that the concept, not the particular stimuli, has been learned. Further, if the teaching

situation employed the discrimination between triangles and squares, the test situation should require other discriminations by use of hexagons, etc. Changes in sense modality and other variations would play a part for some transfer test situations. In any event, one criterion for evaluating a statement of a behavioral objective is that several informed persons could easily agree upon a suitable test.

The basis for planning instruction. Another principal reason for stating objectives in behavioral terms is to insure that the instruction is relevant. For example, a statement to "learn about the Civil War" is obviously inadequate as a basis for planning instruction, although it does imply, to citizens of the United States at least, that the course is in American History. Clearly, more information is needed to decide whether the student is to memorize dates, identify the principal reasons for conflict between the North and South, or use economic concepts and principles in a discussion of economic factors which influenced the military outcome of the struggle. The latter objective would require the conditions for problem-solving, while the others would require the conditions for formation of verbal associations and chains. While it is clear that teachers of history should have a voice in choosing which objectives are to be sought, the decision has to be made explicit before the relevant instructional media can be planned.

Identifying the Type of Learning

For each individual objective stated, the next step is to classify it in terms of some classification system which consists of statements as to how the different kinds of learning may be acquired.

Several possible ways of categorizing types of learning were considered. Conventional distinctions employed in the past by research workers include the following: learning of meaningful vs. meaningless material; rote learning vs. conceptual learning; paired-associate vs. serial learning; motor vs. verbal learning. None of these classifications appeared relevant and usable for the present purposes. Likewise, the distinction between "didactic" instruction and "discovery" learning, often used by teachers, seems too little researched to provide useful guidelines for designing media, except in that research findings regarding some of the components, such as degree of prompting and size of step (reviewed in Chapter V) may be useful at specific points in planning instruction. Furthermore, as shown in Chapter V, the media research literature does not provide clear-cut categories of learning for which particular media have been found successful across subject-matter areas. Statements of categories of educational objectives were also considered, but none reviewed included statements of procedures by which the various categories

might be taught. Finally, reviews of research on single variables in learning, such as contiguity, reinforcement, distributed practice, etc., appeared relevant only for some instructional events, and for certain special kinds of tasks, and hence could not become the basis for sorting of educational objectives for the purposes of planning media of instruction.

The above digression is made to indicate that a search was conducted for the most useful classification system in terms of purposes of the present project. As said before, the categories outlined by Gagne (1965) appeared the most promising of all alternatives considered. In an earlier portion of this Chapter there was presented a listing of the types of learning most frequently found in public education, although all eight of the types outlined by Gagne should be kept in mind when classifying objectives.

Ideally, each behavioral objective would be stated in terms of a sufficiently limited scope of instruction so as to involve only one kind of learning. It is to be noted, however, that the more complex types of learning encompass the less complex types, as discussed in detail in Gagne's book. Instances may be encountered, of course, in which it may be difficult to state a meaningful objective which does not cut across learning categories. In such an event, presumably one would plan the instruction in terms of

component aspects of the total objective which can be identifiable as one type of learning, and then proceed with the analysis in much the same fashion that several objectives in a sequence are handled. A desirable precaution, however, could consist of a second attempt to state the objective by breaking it down into two or more objectives which are unitary in respect to the type of learning. Also, as shown in Chapter III, general behavioral objectives may often first be stated, and then more specific ones which meet the above criteria.

At the time of this writing, then, it appears that the eight types of learning identified by Gagne represent best, for present purposes, a set of categories which are defined in terms of different sets of conditions for learning, and these conditions have been identified by study of empirical findings. While the writers may have wished for a simpler basis for identifying the kinds of learning represented by educational objectives, no simpler method appears to have the same degree of experimental verification. Conversely, the writers tend to feel that almost any method of categorizing is, in many respects, an over-simplification when one thinks of all the external variables which may influence learning. The categories adopted here, then, appeared best in terms of scope covered, the degree of simplicity attainable, and experimental support.

The eight types of learning identified by Gagne (1965) are:

1. Signal learning
2. Stimulus-response learning
3. Chaining
4. Verbal association
5. Multiple discrimination
6. Concepts
7. Principles
8. Problem solving

It is beyond the scope of this report to discuss these types of learning separately in detail, and this has been done by Gagne (1965). However, some references have been made in this report to particular features of some of these types of learning as to their importance in education.

The remaining point to be mentioned here, on the topic of identifying the type of learning represented by a given behavioral objective, refers to a suggested aid in making such classifications. The suggestion is that some brief outline of the eight types of learning may be used as a reference when trying to decide which type of learning is represented by a given objective. One such outline for several types of learning is presented earlier in this chapter. The author of Chapter III, when making the analysis presented there, made a chart consisting of eight sections, one for each type of learning. In the chart, for each type of learning

there were entries consisting of (a) the category name, (b) alternate names (like shaping, connection, and discriminated operant, for the stimulus-response learning category), (c) examples of such learned behavior, (d) the general conditions required, and (e) the instructional steps implied. Such a summary chart may be most meaningful if prepared by the person who is to do the analysis while he studies Gagne's book. Probably different cue words would constitute the maximum aid for various persons doing such analyses, depending upon their prior backgrounds and orientations. It is for this reason that the particular summary chart mentioned here is not reproduced in this report.

Designing a Media Program

This step involves the examination of each objective, in turn, in order to state the explicit instructional steps and the media by which the required conditions of learning could be established.

One first notes the type of learning represented, as identified by the previous step in the process. He then recalls (perhaps with the aid of a summary chart, as discussed in the previous section of this chapter) the (a) general conditions of learning for that category. For example, for chaining, one condition is to provide contiguity of one link with the next. One next identifies (b) the content to be dealt with; in this example it would be the two links to be chained,

like "sodium chloride." One next asks himself (c) how he will provide contiguity, and (d) in what exact stimulus form the two links are to be presented contiguously. Probably he would decide upon point (d) before point (c) in this instance, as he would wish to decide whether the student should see the words in printed form, or hear them spoken, or see or hear them in further contiguity of the notation NaCl. If printed words are chosen, he then decides how these stimuli (printed words) are to be presented in contiguity. Alternate choices are in the form of a book, flash cards, projected slides, teaching machines, or films, and probably many others. The actual media choice will probably hinge on the instruction that precedes and follows this item of instruction.

The above example probably would constitute only a part of a behavioral objective, but it was chosen to show the degree of minute detail which may often be involved. Statement of the instructional events, for this example, in addition to identification of a way for presenting the stimuli in such a way as to provide contiguity, would further hinge upon the estimate of whether more than one presentation is needed, whether only two, rather than more stimuli, are to be presented in a single presentation, and whether overt responses and feedback are required. These decisions, in turn, would hinge in part upon whether the student is to spell the words or only pronounce them

as a chain, and upon pre-requisite knowledge, such as whether the words, used separately, are already words which are recognized and spelled correctly.

As indicated above, this degree of detail in analysis may be necessary for several component parts of a behavioral objective such as "Be able to say either the words or the symbols for the following chemical compounds, whether the words or the symbols are the given terms." In this instance, all such components of the objective appear to fall into the same kind of learning, except for compounds of elements in unequal proportions, in which case the use of subscripts as principles is also required, in connection with suffixes such as -ic and -ous. (Later on in the instruction, of course, new or unfamiliar compounds may be identified without direct instruction as simple cases of problem solving,)

It is recognized that a teacher may not wish to teach the above objective as a set of chains to be formed. This would make a great difference in how the instructional events, as well as the media, would be arranged. For example, if students are to induce such chemical expressions by first learning to apply the principles by which such designations first came to be constructed, then it is likely that motion pictures, using animation techniques for showing how elements combine into compounds, might constitute the media for early instructional events. This basic decision is essentially a curriculum

approach decision, and it must be made before the media schedule is drawn up, as different types of learning would become involved. (It may be noted, in passing, that the arguments for or against "discovery learning" should probably be broken down into two different and independent sets of considerations, rather than seeking a general "answer." Education involves both (a) learning what other people already know, and (b) preparation for achieving new discoveries. Education also involves several kinds of learning. Discovery learning should be considered in the light of these factors.)

At this point, the reader may wish to inspect examples of media programs for specific objectives, such as those presented in Chapter III. Each objective may involve some variations in the exact order in which one makes notations regarding (a) general conditions for the type of learning, (b) the instructional events, (c) the content, (d) the nature of the stimuli, and (e) the alternate available media of presentation.

Also, as noted earlier, some of the instructional events are the same for several kinds of learning, and some are different. That is, presentation of stimuli (words, pictures, etc.) and appraisal (and feedback for the student) are common requirements, while progressive part practice, stimulating recall of relevant concepts, and confirmation of overt responses are requirements special to some kinds of learning.

It is to be noted that, at this step, one may make note of possible media options without making media decisions. Thus the media schedules, for each objective, are the raw materials from which media decisions are later made, in which sequencing, economy, and other factors are taken into account. In this sense, the present step is the most analytical step, and it is best made in terms of technical knowledge about the conditions of learning, temporarily divorced from other practical considerations.

Finally, it should be noted that, depending upon how general or how minute are the statements of behavioral objectives, the media program may be made for an entire objective, or for only a component of an objective. In the above illustration involving "sodium chloride," a rather minute segment was chosen in order to illustrate some of the details which could be involved. It may be noted that the media program, for some objectives, is made in as much detail as would be given in the final lesson as presented by a medium of instruction. In this sense, the media schedule is the "program," used in the way meant in "programed instruction." In other cases, the media program could represent only the guide to the programmer on how the lesson is to be prepared in the medium chosen. This difference in detail is illustrated in Chapters III and IV.

The functions of stimuli. It was said, in Chapter I, that all that the instructional media can do is to provide external stimuli.

However, these stimuli may, or must, for various kinds of learning, serve many instructional functions, such as: (a) set a goal in terms of performance desired, (b) direct attention, (c) present instructional content (also stimuli), (d) elicit responses, (e) provide feedback, (f) direct the next effort, and (g) help the student evaluate his performance. Other special functions of stimuli are to (a) provide the degree of cueing or prompting desired, (b) enhance motivation, (c) aid the student in recall of relevant concepts, (d) promote transfer, and (e) induce generalizing experiences. A general discussion of the capabilities of various media in providing these instructional functions has been presented by Gagne (1965, Chapter 10). The task of considering the possible media alternatives for each required instructional event for each objective takes place when designing the media program.

Sensory modes and dimensions of stimuli. For most of education, the eye and the ear are the primary sensory modes stimulated by instructional media. However, for young children and for special purposes, the senses of touch, taste, smell, and kinesthesia may be quite important. These include impressions of hot, cold, rough, smooth, pressure, pain, etc. In athletics, for example, movement-produced stimuli are highly important, and since these are internally produced, the instructional events are arranged to make more probable

the experiencing of the desired internal stimuli which accompany successful physical acts. Thus the learner's hand may be guided by the teacher primarily to produce, for the first time, the "correct" skeletal movement which produces the desired internal stimuli in the only practical way they can be produced. However, these instances are more the exceptions than the rule, when all of education is considered.

Nevertheless, an important consideration in the preparation of the media schedule is the decision of whether to stimulate the eye, the ear, or another sense organ, since media alternatives obviously are directly related. In spite of the amount of research conducted on visual versus auditory stimulation, not many generalizations appear useful for the purpose of designing the media schedule. For example, children could learn to recite poetry by reading and prompted recitation trials, or by hearing and prompted recitation trials. The instructional decision would probably be made on the bases of convenience and age of the child, e.g., whether he can read or not. In some instances, especially when one performs with the aid of prompts in the criterion situation, the instructional media should probably provide the prompts by stimulation of the same sensory modes as stimulated in the criterion situation.

Normally, however, the determination of the sensory mode to be stimulated does not, in itself, necessarily identify the media to

be chosen. For example, visual stimuli may consist of printed words, natural objects, pictures, drawing, or moving objects. These may be presented in the form of books, slides, motion pictures, programmed instruction, or as real objects. Sounds may consist of words spoken by the teacher, or sounds recorded on tape, or sounds from natural sources (e.g., sound of bells). Thus, visual and auditory stimuli may be presented in various degrees of size, intensity, duration, etc.

The choice of the medium often may rest upon the convenience of incorporating a way to automatically evaluate the student's response and provide feedback. That is, a drawing may be placed on a wall chart, but its instructional function may be enhanced by an explanation by the teacher or by responses elicited by cues in a programmed instruction booklet.

The choice of the medium also may hinge upon the best means to attain the particular dimensions desired for the stimuli. One dimension may be the choice of audio, visual, or audiovisual channels. The form may consist of words, symbols, pictures, or signals. A third dimension is size, area, and amount of presentation to be given in temporal sequence, including intensity, color, or pacing of successive stimuli. The schedule of interruption of "content" stimuli to allow for responses, feedback, goal setting, and evaluation is another dimension in selecting media of presentation. Exposure rates, as

in fast or slow motion, and size of step in terms of rapidity of progression from simple to complex, constitute another dimension. Other factors in the final media choices are discussed in the following section.

Preparing Summaries of Sequences of Media Alternatives

Once a media schedule has been prepared for each objective in a sequence of instruction, it is necessary to inspect them all in some overall fashion in preparation for making final, practical media decisions. It is useful, then, to first prepare some kind of summary of the media alternatives from the media schedules for the individual objectives. Such a summary, for a short sequence, may be made implicitly by simply reviewing the options in the individual media schedules. At other times, a written summary, such as is illustrated in Chapter III, may be helpful.

The purpose of this step is to review the media options previously noted, in order to identify the best medium (or media) for some reasonably-sized unit of instruction. If a given medium option appears only once or twice in the summary, whereas another medium appears very frequently, consideration could be given to the possibility that the second medium could also serve the purpose of the first. In the process of such deliberations, one could deter-

mine that one option noted has a critical capability no other medium appears to provide. In this case, a quite brief presentation in one medium could be justified in spite of the greater convenience of simply adapting the entire sequence to the most frequently appearing option in the summary.

Another reason for preparing such a summary sheet is to detect the possibility of changing the sequencing within a segment, or between segments, to make the presentations by the various media flow more smoothly, or with less inconvenience or lost time in the classroom.

Just how often one should pause to make such summaries cannot be stated with confidence. In some instances, a major course objective may be represented by the content of the summary. In other cases, one may note a definite change in the particular options recorded at a particular point in the individual media programs, and be able to clearly recognize when a major medium change can be anticipated in advance. In any event, these summaries may be considered as aids in taking the next step in the procedure.

Selection of Media

It is at this point that one seeks ways to plan to use a single medium for the optimum length of time for the most appropriate set of objectives, without doing serious violence to the ways of providing

the instructional events indicated as needed in the media schedules, and with minimum violation of cost and convenience considerations. It is at this step that final compromises and changing in sequencing may be considered.

It is also at this point that one must decide among the alternatives of group instruction, individualized instruction, teacher-conducted instruction, and automated instruction, with further specification of allowable assumptions regarding costs and equipment to be available. Of course, if one has a clear view of these factors at the outset, and if stated limitations in these respects must prevail, this would influence the work done at earlier steps in the analysis.

For purposes of discussion however, it is assumed that a group of educational specialists is conducting the analysis with the view that it would be possible to provide specifications for alternate packages of instruction in a widely-required course, so that different media packages might be prepared to suit local budget limitations, or to permit more latitude in the local options based on preference for automated or non-automated, and individual or group instruction. Stated differently, the analysis at this point could be based on either the assumption of (a) unlimited funds and the possibility of designing new equipment for this instruction, (b) presently available

equipment and techniques with cost not an over-riding consideration, or (c) some more limiting set of assumptions. In Chapter III, the effects of such alternate restricting conditions are shown in terms of packaging options for the instruction.

In any event, it is at this step in the procedure that the choices of media are reviewed in terms of such practical matters as how many items requiring the same set of learning conditions can be sequenced in a row to provide a long enough period of use of a given medium to make it economical to make a small instructional package. This factor interacts with the flexibility of the medium. For example, it is easier to alternate between presentation of information, student response, and feedback in a programmed instruction sequence than in a motion picture sequence.

Suppose flash cards are good for establishing certain verbal associations, and programmed instruction is effective for establishing certain concepts. Can the sequence be arranged to permit use of flash cards for a period of several minutes before using a programmed instruction sequence taking several minutes, or must the student learn one verbal association and one concept alternately? If so, a "compromise" medium will probably be selected.

Again, if one needs to present high-fidelity music for a few seconds at a time, interspersed with short spoken statements, will

a high-fidelity recording be unnecessarily used for the spoken statements to get a smoothly-packaged sequence, or will the teacher start and stop the record frequently to interject the commentary?

Such practical considerations will often force a choice between adopting an "awkward" way to switch from one chosen medium to another rapidly, and choice of a less effective or less economical "compromise" package for the sake of convenience. Ideally, and possibly in the future, practically, improved budgets and new kinds of equipment will make such compromises less frequently necessary.

The degree of latitude in choice possible at this step rests, in part, on the fact that most media are "general purpose" devices, e.g., they are not designed for any specific subject matter. (It is necessary, of course, to recognize a further distinction between equipment and the instructional material. Projectors and teaching machines are general-purpose devices, while the films and programs used in them are designed for specific instructional purposes. The ambiguity in the definition of "media" is that both kinds of items are included by this term as used, e.g., "media are physical means of presenting stimuli.") Exceptions, however, include laboratory equipment, simulators, and other specialized "training devices." Most media are also "general-purpose" devices in that they may be programmed to teach facts or principles, as well as concepts and problem solving. Excep-

tions may be flash cards (used for memorizing) and tuning forks (to teach pitch discrimination). A further aspect of the flexibility of some media is that they permit considerable latitude in stimulus dimensions -- spoken words, pictures of action, diagrams, printed words, etc., as in TV and motion-picture films, and words, pictures, diagrams, and provision for eliciting explicit responses and of providing feedback, as in programmed instruction.

For these and other reasons, if only presently available equipment and techniques are considered, there is seldom any one ideal way to present a very lengthy sequence when all factors known, relating to learning conditions and practical constraints, have to be viewed in a trade-off fashion. Nevertheless, the closer the final media choices can adhere to the media shown in the media programs for the individual objectives, the greater the likelihood that the result of the analysis will be a multi-media package of significantly greater effectiveness than could be achieved by a less systematic approach to the design of instruction.

While the present writers see no simpler way of designing instruction while preserving the analytic framework upon which the procedures here recommended are based, it remains for future research efforts to reveal whether present knowledge can be cast into a simpler structure for this purpose. In fact, when one considers the possible

addition of individual difference variables and situational variables to the present treatment of learning condition variables, one must expect a more complex, rather than a less complex, improved version of the method of analysis. Whether the increasing uses of computers in education could become the key to the application of a more complex, semi-automated system of analysis will not be speculated upon here. However, the writers do wish to reiterate that the solution to this problem should rest upon the most dependable and relevant research findings available, and that resort to the all too familiar "media comparison" study, which does not classify and identify the learning objectives in a generalizable fashion, cannot result in the kind of improvements sought. Such studies would have usefulness, however, in the field testing of the present procedure in comparison with any proposed alternate procedure.

Preparing the Specifications

After the above step has resulted in identification of the specific instructional sequences (of whatever size) which are to be presented by the various media, specifications are then prepared to serve as guidelines for the text writer, the self-instructional programmer, the motion-picture producers, and the other production specialists whose skills in working in the various media are to be utilized.

As noted earlier, in some cases, these specifications may consist of the actual words and pictures to be presented, so that the remaining task is simply that of reproduction of the material. In other cases, the specification would leave developmental work to be done by the media specialists. For example, a specification may call for use of animation and three-dimensional models of the sun and the earth, with motion, shadows, and narration to enable the student to learn how the seasons and night and day come about. Criterion questions would be furnished, but the producer might be given the task of writing the script he believes would enable the student to pass the criterion test.

Conducting Tryout and Revisions of the Materials

Whether the specifications are actually verbatim scripts or directions for scripts, they should include criterion tests and directions to the classroom teachers. Then, empirical tryout and revision procedures could be employed before general use of the products. For the teacher's use, some guidelines could consist only of the sequence in which automated segments are to be presented, plus suggestions for appraisal and generalizing experiences. For teacher-conducted sequences, more detail would be needed.

Individualized sequences. One rather natural advantage of the approach here recommended is that sequences of instruction are delivered in relatively small packages because of the use of various media. This fact fits in nicely with the idea of individualized flexible curricula, in which not all students would take all sequences, even in a required course. For example, a course might begin with instruction and review of arithmetic, so that all the pre-requisites for business arithmetic and algebra are achieved by all students. Then special sequences could be used in a branching fashion so that students in a vocational program would receive somewhat different instruction from that received by those in a college preparatory program. Less radical differences in content could further be introduced within the two sub-groups, based on individual goals and achievements.

Thus, while planning of instruction is accomplished by a single body of educational specialists, implementation of the instruction could rest not only upon local options within school districts, but also upon individual variations in curricula (and perhaps also teaching method) within a classroom.

CHAPTER III

An Illustration of the Analysis Procedure for A Group of Objectives from A Course in Elementary Science

Leslie J. Briggs

Introduction

The illustrative analyses of the particular group of objectives chosen for the purposes of this chapter are probably typical in some respects and atypical in other respects of problems which may generally be encountered in the process of analyzing educational objectives, for the purpose of choosing the media of instruction.

The analyses presented here are typical in the sense that each objective, as stated, could be identified as to type of learning judged to be represented. Other typical features include the following: (a) the nature of the stimuli desired had to be considered in terms of the specific objective as well as in terms of the conditions of learning sought, in order to record media alternatives in the media schedule; (b) actual choice of the media hinged finally around matters relating to sequencing of instruction, convenience in classroom procedure, and equipment (or lack of equipment) assumed to be available; (c) alternate ways to package the sequences could be

derived from the analysis, depending on different assumptions made regarding equipment availability and group versus individual instruction, thus giving rise to recommendations in the context of both present and future sets of circumstances; (d) the age (prior experience and knowledge) of the learner had a limiting influence on available media alternatives; (e) careful ordering of the sequence of objectives took advantage of expected transfer effects, and (f) several media, it was shown, could serve equally well if decided upon the basis of some of the above considerations.

Some features of this analysis, which are atypical of many situations which may be encountered for other grade levels or other courses, include the following: (a) the original statements of objectives were cast in behavioral terms, as recommended in Chapter II of this report; (b) the objectives had been organized in a hierarchical structure which permitted some latitude in sequencing of instruction while benefitting from transfer effects from the sequencing chosen; (c) the grade level of the students for these objectives included the kindergarten and first grade, so that media requiring reading by the student were precluded; (d) as a result of the age of the students, substantially fewer competencies could be assumed as pre-requisites for the instruction than would be the case for older children. This latter point, it was thought, made the analysis a more challenging

one, on one hand, but it also resulted in failure to illustrate use of media requiring reading ability, on the other hand. However, in view of the analyses presented in Chapter IV, the two sets of analyses presented in Chapters III and IV taken together, it was thought, represented some balance by way of complementary illustrations.

The Source of the Objectives for This Analysis

The objectives chosen for analysis in this chapter were first stated in behavioral terms. It appears desirable to examine the significance of this point in some detail.

The objectives were taken from an experimental science curriculum sponsored by the Commission on Science Education, under a grant from the National Science Foundation to the American Association for the Advancement of Science. This experimental course, called Science -- a process approach (American Association for the Advancement of Science, 1964a, 1964b), was founded on the concept that the purpose of teaching science in the elementary and intermediate grades is to train the child's skills, from an elementary level to more complex levels, in applying the same intellectual processes which are used by adult scientists in their work. The course was developed by a distinguished group of teachers, scientists, and psychologists. The child is first taught to use his sense organs to make valid inferences, observations, and classifications about natural phenomena. Later he

is taught the advantages of using measuring instruments to obtain more accurate observations, and hence better inferences. He also learns that not only do his sense organs give less precise data than is possible with the use of measuring instruments, but he also learns that some of his perceptions are illusory. Later yet the child learns to design experiments to answer questions not answered by casual observation of events and objects as they occur naturally without use of apparatus and hypotheses. In short, while the children are not made into mature scientists by this curriculum, they do acquire skills upon which later scientific training can be based. Of yet broader importance, all children are taught skills needed by any adult or child in his everyday activities.

Children in the primary grades (beginning with kindergarten) acquire elementary skills in the following processes (behaviors):

1. Recognizing and using space/time relations.
2. Recognizing and using numbers and number relations.
3. Observing.
4. Classifying.
5. Measuring.
6. Communicating.
7. Inferring.
8. Predicting.

In intermediate grades the children acquire and use more complex skills in the above processes, and these skills become integrated with the following processes:

1. Formulating hypotheses.
2. Making operational definitions.
3. Controlling and manipulating variables.
4. Experimenting.
5. Formulating models.
6. Interpreting data.

Having established the behavioral objectives (processes), content objectives were then chosen from any applicable field of science or nature. One exercise in observation, for example, may employ materials from geography, and the next from physics or psychology. Thus one subject matter is not defended as the only relevant way to develop the process -- in fact, great care is taken to be sure that the process skills learned can be applied by the child in use of any science materials or subject matter.

For the purpose of the analysis presented in this chapter, a beginning segment of the behavioral objectives relating to measurement skills was selected from the AAAS science curriculum. These objectives, for all grade levels involved, had originally been arranged in hierarchical form. This total hierarchy for measurement

objectives is found in Science -- A process approach: Commentary for teachers (American Association for the Advancement of Science, 1964a, pp. 58-60).

The procedures specified in the publication cited immediately above do not presume the availability of specialized audiovisual equipments. Rather, group, teacher-administered activities are designed, using commonly available physical materials and simple laboratory apparatus. The reason for this is that the course is now in experimental use, and is thus adapted to present classrooms, equipment, budgets, and teacher-pupil ratios. While individual initiative and discovery efforts are stressed heavily, the mechanisms needed to individualize instruction fully are not assumed to be available. At some points in the analysis which follows, media choices are made within the above constraints. At other points, however, especially to show options by which instruction could be individualized, these constraints are not assumed to be in effect.

Selected for this illustrative analysis were the first five measurement objectives, all designed for the kindergarten and first grade. The title for each objective or lesson is given below in abbreviated form, after which the behavioral objective is stated for each lesson as the first step in the analysis.

1. Comparing lengths -	Kindergarten
2. Linear measurement -	Kindergarten
3. Metric measurement -	First Grade
4. Making comparisons using a balance -	First Grade
5. Comparison of volumes -	First Grade

Analysis for Objective No. 1

Step 1.

Objective: Given pairs of objects he is allowed to manipulate, the child can point to the "longer one" and the "shorter one" of each pair, or say "they are the same length." (Standard: Student is consistently correct for differences exceeding 1/4 inch.)

Comment: Since this objective is for kindergarten children, written words are ruled out in the selection of media. No prior knowledge is assumed for the words "long" and "short," though if known they should serve as strong prompts for "longer" and "shorter."

Step 2.

Type of learning: Acquisition of the concepts "longer than," "shorter than," and "same length."

Step 3. Instructional Event

Conditions of learning: Ability to make visual discriminations of differences in lengths of objects is a pre-requisite skill, or becomes automatically made in presence of the stimuli, or is prompted out by the teacher's verbalizations and demonstrations of "side by side," and "none left over" or "some left over". These same verbalizations are acquired by the child as verbal-association responses to his own perception of equal or unequal members when presented in pairs; e.g., the image is chained with the words. These discriminations are practiced under a variety of conditions (e.g., the child responds to questions like "which is not the longest one?") to provide stimulus generalization. Also a variety of materials is used for the purpose of being sure that the essential property of "length" is responded to regardless of type of object presented. Response generalization is tested for by using different materials in the test situation, and by the way the teacher states the question.

Media program (for a concept)

<u>Instructional Event</u>	<u>Medium</u>
1. Present two stimulus objects of grossly unequal lengths.	1. Two dowels, one 4" long and the other 12" long. Alternate media: life-size pictures of the same objects.

Instructional Event

Medium

- | | |
|---|--|
| 2. Stimulate recall (or learning) of "large" one. | 2. Teacher says "large" and "small" when holding up appropriate object. |
| 3. Stimulate recall (or learning) of "small" one. | 3. The two dowels; teacher requests children to hold side by side and verbalize answers. |
| 4. Make the distinction more difficult. | 4. 4" and 5" dowels held a wide distance apart. |
| 5. Use student responses to show difficulty of judging. | 5. Two dowels held far apart lead to inaccurate decisions by students. |
| 6. Provide guidance; demonstrate advantage of side-by-side placement to decide "longer" etc. (Identify "left over" or "same" as critical distinction, then label of each is practiced by children ("longer," "shorter," "same.")) | 6. Two dowels held close together. |
| 7. Present variety of lengths of pairs and variety of materials. | 7. Dowels, pencils, soda straws, sticks, all varying greatly in length among and within pairs. |
| 8. Provide confirmation. | 8. "Yes" and "no" by teacher, plus request to repeat exercises when needed. |
| 9. Appraisal. | 9. Other pairs of objects, which differ in length; e.g., rulers, boxes, pointers, etc. |

The objects or life-sized pictures of objects specified in the above media program as media alternates may be employed for either teacher-conducted group instruction or for individualized, automated instruction as indicated below.

Group instruction. Teacher holds up selected pairs, identifies and verbalizes "longer" and "shorter" when objects are placed "side by side" (using "long" and "short" if known by children as prompts). Demonstrates "left over" and "the same" as basis for learning the labels "longer," "shorter," or "equal." Teacher alternates using objects and her spoken words, with children's spoken responses to objects. She assigns variety of pairs of objects to children to manipulate, and provides feedback to their responses. Much of this practice and feedback should be done with individuals after opening demonstrations. (Group feedback may be very risky in this situation.)

Automated instruction. A sound tape and slide display could be employed to provide individualized instruction, in order to achieve individual practice and more accurate feedback. This would be a more dependable feedback method, provided that the child can reliably operate "red" and "green" buttons for indicating his answers in order to receive pre-programed auditory feedback. In this event, the child may gain the generalizing advantage of matching "real"

sticks or dowels with ~~others~~ projected life-size on a screen, thus acquiring familiarity with visual displays which can continue to be used as an instructional procedure for the child. Possibly such an automated lesson, first taken under guidance of a teacher, would confirm the child's ability to operate the control switches properly to be able to continue this form of instruction. (That is, discriminating red from green answer buttons could be established if the discrimination is absent at the start).

While it would appear economically unsound, at first glance, to make a motion picture film as another form of individual instruction for such a lesson, an advantage of a motion picture could be to dramatize the usefulness of "side by side" comparisons in contrast to two objects a distance apart. This "distance" effect could be accomplished better with the motion picture medium than in the teacher's demonstration or with still slides. Assuming some transfer of sensory exercise from home TV watching, ability to respond to motion pictures as adults do, perceptually speaking, perhaps should be developed and capitalized upon, beginning with the kindergarten level.

Analysis for Objective No. 2

Step 1.

Objective: Demonstrate a method for using a measuring stick to determine whether two objects, separated in space, are the same length.

Step 2.

Type of learning: Principle learning: "Two objects equal to the same thing are equal to each other."

Step 3

Conditions of learning:

- (a) Individual concepts must have previously been learned ("longer," "shorter," "same length.")
- (b) The principle must be stated to the child and demonstrated, or it must be discovered by the child.
- (c) Several examples of application should be experienced to be sure that more than the verbalization of the principle is learned.

Media program

Instructional Event

Medium

1. Inform learner about performance required

1. Two sets of dowels are mounted on separate wall displays. Each set has members of different lengths. Problem is how to identify the members of the same length in the two sets. (They cannot be moved.)

Instructional Event

Medium

- | | |
|---|--|
| 2. Stimulate recall of component concepts. | 2. Child is led to recall how to find out if lengths are equal by side-by-side placement of objects. |
| 3. Verbal prompting. | 3. "Here are some loose dowels that can be moved. Would they help?" |
| 4. By discovery or prompting, principle is stated: If a movable dowel is equal to two others, as shown by side-by-side placement, the two others are the same length. | 4. Children use loose dowels to make side-by-side comparisons to identify equal members in the two display sets of dowels. |

For this objective, also, media alternatives may be selected for either individual or group instruction. For group instruction, the two displays and the loose dowels are viewed and matched. Verbal statements by the teacher present the performance sought, and either provide or prompt the statement of the principle. Children make several matchings, using different movable sets of dowels, straws, pencils. (Again, a motion picture might present this principle, but having real objects to manipulate might accelerate this application of side-by-side placements.)

Automated individualized instruction could be designed by use of slides and sound track, with use of the same kind of AV responding arrangement discussed for objective number one.

Analysis for Objective No. 3

Step 1.

Objective: Child can select a measuring stick and count how many times it can be laid end-to-end along a linear dimension to be measured.

Comment: Kindergarten; no reading ability; pre-requisite: child is able to count at least up to 10.

Step 2.

Type of learning: Problem solving.

Step 3.

Conditions of learning:

- (a) Learner must know that the linear length to be measured is to be expressed by "number of times" a measure is applied, not by "same," "different," or "shorter."
- (b) Relevant principles recalled for dealing with lengths of objects.
- (c) Use of counting along with use of a measuring stick must be seen in combination to solve the problem.
- (d) Once found, such solutions are often very resistant to extinction.

Media program

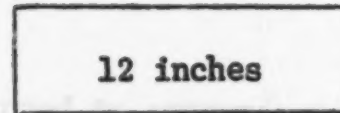
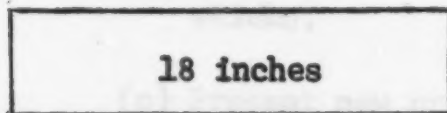
Instructional Event

Medium

- | | |
|--|---|
| 1. Pose problem of how to find whether two tables at opposite sides of the room are the same length. (Neither must be moved.) | 1. Teacher spoken words. |
| 2. The previous methods of using sticks to measure immovable objects are recalled. | 2. Teacher-conducted discussion. |
| 3. Present problem, "But all the sticks are much shorter than the tables." How can they still be used? | 3. Teacher gives prompt to associate "counting" with use of a measuring stick. |
| 4. Introduce selection of measuring stick. | 4. Teacher uses 1" and 10" sticks to show that use of the longer one takes less counting to measure a table. |
| 5. Children practice measuring the two tables with sticks of different lengths. The "count" varies by length of stick, but results are the same, they discover, as long as the same stick is used. | 5. Teacher provides feedback to show that any length of stick can be used to find that tables are of equal length. (In this exercise, the expression "between 5 and 6 inches" is used rather than fractions.) |

Media alternatives available for group or for individual instruction are similar to those discussed for the preceding objectives. A good generalizing experience which would prepare students for later use of symbolic ways of manipulating linear quantities might consist

of "pictures of two boxes":



Child uses smaller sticks (3 or 4 inches long) to find that boxes are unequal: one is "3 sticks" long and the other is "over 4 sticks" long.

Analysis for Objective No. 4

Step 1.

Objective: Child is able to select the most convenient of several standard measuring sticks to measure length of such objects as a crayon, a pencil, a book, a desk, the length of the room. He reports measurements such as 4 centimeters, between 7 and 8 decimeters, and 8 meters.

Comment: First grade.

Step 2.

Type of learning: Concepts (meter stick) (standard).
Principles (10 decimeters equal 1 meter).
Verbal chains (counting decimeters in a meter).

Step 3.

Conditions of learning:

- (a) Present new stimuli (standard measuring sticks).
- (b) Recall use of earlier (unstandard) sticks to measure

length. Practice the familiar way, with the unstandard sticks.

(c) Present new principle of need to communicate results so they will mean the same to everybody (metric system).

(d) Practice counting to learn equivalence of units.

Media program

Instructional Event

Medium

- | | |
|--|---|
| 1. Recall previous measurement lessons (in which children gave their own names to measuring sticks, to emphasize their non-standard nature, and reported results as "3 sticks," "4 gloops," "5 dashes," etc.). | 1. Teacher discussion or review sequence of slides and tape narration, or motion picture. |
| 2. Present problem. (There is no standard relation to name of a stick and its length. Problem in communication.) | 2. Teacher discussion; or film or slides. |
| 3. Dramatize the problem. (Two children have sticks both called "gloops." Each child measures a desk - one reports 10 gloops and the other 6 gloops.) | 3. Two "gloop" sticks used by children; or movie of same situation. |
| 4. Present standard measuring sticks. | 4. Meter, centimeter, decimeter. |

5. Repeat step 3, having decimeters used by two children.

5. Both children report, "The desk is 10 decimeters long." Teacher emphasizes the value of this when communication takes place in absence of the measurement operation.

6. Discuss value of decimeter.

6. Teacher cues discussion.

7. Present factors in choice of best measure. Disadvantage of decimeter stick for measuring length of room, or meter for measuring a pencil (have to count too high or encounter "parts of a unit").

7. The three standard measures and objects in the room.

8. Final relation of decimeter to meter (just like measuring a table with sticks).

8. Children mark off ten decimeters on a meter stick.

9. Using convenient measures.

9. Child practices with different objects and measures, reporting results, and showing why selected measure is appropriate (avoid fractions or too much counting).

Again, media options could entail variations discussed previously.

In group instruction, the teacher's comments are combined with the child's use of the physical objects for demonstration and measurement. The child gains facilitation in making measurements with appropriate measures, and reporting results to nearest whole number. Children may discover applications of the decimal system to translate from

one measure to the other.

This same exercise could be prepared in the form of slides and tapes, to give the child experience in seeing a meter stick in comparison to a decimeter stick in small-scale form in pictures, as a preparation for adjusting "real life" units to scaled-down illustrated units (just as a picture of a horse, though smaller than a real horse, is to be reacted to in the "real" dimension.)

Analysis for Objective No. 5

Step 1.

Objective: Correctly order the volumes of various containers, and prove correctness of ordering in terms of the number of a unit-of-volume each one contains.

Step 2.

Type of learning:

Concept (volume)

Principles (use of shapes of containers of irregular shape,

and use of dimensions of containers of regular

shape, as cues in estimating relative volume; use

of a unit-of-volume to correct or verify estimates of relative volume).

Step 3

Conditions of learning:

- (a) Knowledge of the performance requirement (arrange containers in order of their volume).
- (b) Stimulate recall of component or relevant concepts (recall standard linear measure; need for volume measure).
- (c) Verbal cues. (How can we use a unit of volume like we used a unit of linear distance?)

Media program

Instructional Event

Medium

- | | |
|---|---|
| 1. Ask which of two containers would hold more water. | 1. Quart and pint jars, of regular shape, e.g., cylindrical, or pictures and filmed demonstration of the same. |
| 2. Ask how this could be proved. | 2. Pour water (colored) from one jar to the other to note "not filled" and "overflowed" as check upon judgment. |
| 3. Ask how many units of water one jar holds. | 3. A third, smaller, jar to serve as "unit" of measuring volume. |
| 4. Introduce use of unit. | 4. Count number of times the unit is needed to fill various jars. |

- | | |
|--|---|
| 5. Cue relations of dimension of two regular jars in relation to volume. | 5. Quart jar is taller and wider than pint. |
| 6. Introduce difficulty of estimating for irregularly shaped containers. | 6. Number of salad dressing bottles of various shapes, or pictures of the same. |
| 7. See relation of average diameter for jars of same height. | 7. Fill various bottles with unit measure to improve upon estimates made. |
| 8. For communication, recall metric system and need for standard unit of volume. | 8. Show relation of pint to various bottles and jars. |

Step 4

Media Summary Sheet for Objectives 1-5

Objective

Media

Number 1

- a. Dowels (4" and 12").
- b. Verbal statements by teacher.
- c. Questions posed by teacher.
- d. Verbal feedback by teacher.
- e. Pencils, soda straws, sticks.
- f. Slides, tapes, or motion pictures of same.

Number 2

- a. Two displays (mounted), each containing several dowels of different lengths.
- b. Teacher verbally states problem, and provides feedback.
- c. Group of "loose" dowels.
- d. Or pictures and tapes of same.

Number 3

- a. 1" and 10" sticks.
- b. Teacher statements.

Number 4

- a. Two "gloop" sticks.
- b. Meters, centimeter, decimeter, measuring sticks.
- c. Objects in room.
- d. Teacher statements.
- e. Student statements.
- f. Pictures and tapes portraying same.

Number 5

- a. Quart and pint jars.
- b. Colored water.
- c. Small unit jar.
- d. Bottles of various shapes.
- e. Teacher and student statements.
- f. Or, movie sequences of same.

Step 5

Generalizations from Analysis of Objectives 1-5

The analyses of five objectives for the kindergarten and first grade children in the measurement sequence of Science -- a process approach, as presented on the preceding pages, gives rise to the possibility of making several summary statements and to discussion of alternate strategies of teaching.

The media which are listed in the above summary sheet may be classified as follows:

1. Common objects: jars, sticks, meter stick, desks, room dimensions, water, pencils, books.
2. Teacher statements.
3. Responses of other students.
4. Equivalent stimuli by slides, tapes, or motion pictures, plus handling of the actual objects.

These concrete objects and verbal statements by the teacher and other students or the automated equivalent of these, all taken together, seem to (a) direct attention, (b) pose problems, (c) cue learning responses, (d) present stimuli for making responses, (e) guide thinking and provide feedback. It must also be supposed that the child's perceptions (e.g., longer than) were also important "media" in that they were internal stimuli which became linked to verbal (confirmed) responses.

What generalizations might be made from the above observations which might be applicable to selection of media for other segments of instruction in kindergarten and first grade? The following appear tenable:

1. Written words must be ruled out as media.
2. Words spoken by the teacher, coupled with use of physical objects, can carry the burden of instruction.
3. Children's perceptual responses to the objects shown and manipulated are important mediators of the performances learned.
4. Physical manipulation of objects facilitates formation of needed perceptual and motor responses.
5. Words spoken by other children must be an important source of instruction at this level, especially when

the child is working with a small group without feedback from the teacher.

6. Little use was prescribed, in the teacher-conducted form of instruction, of pictures of objects rather than the actual objects. Yet all these exercises could be made into motion-picture demonstrations, or slide-tape individualized exercises. Since this has not in fact been done, we have little evidence of the relative merit of seeing and handling actual objects as compared to well-designed motion-picture sequences or slides and tapes supplemented by overt practice. Since the total array of objects and materials used in the entire course, Science -- a process approach, appears overwhelming from the logistic point of view to many teachers, it would be a fertile research field to compare the learning from the "live demonstrations" with learning from film sequences which could be made, supplemented by some manipulative experiences.
7. In comments on media alternatives, it was suggested that audiovisual devices represent a possible compromise between motion pictures and "live demonstrations,"

since by use of AV to give directions and feedback, it could be arranged that the child would handle the real physical objects himself each time, rather than "watching" part of the time as in the teacher-conducted procedures, or as in a motion-picture procedure.

8. In the analysis for each of the five objectives, under the column medium, were listed the objects and spoken words employed. The term media, at that point, distinguished among spoken words and visual images of objects. Note that the entries under "teacher spoken words" could be translated to "tape-recorded words provided by an AV device," or "sound track of a motion-picture film."

Discussion

The Capabilities of the Several Media

In the Introduction to this chapter, there were outlined features of the illustrative analysis presented here, for the particular objectives chosen, which made this "illustrative analysis" both typical and atypical of other analyses which might be undertaken. It is perhaps to be expected that analysis of other objectives, which might

have been selected for purposes of illustration, could have resulted in variations in details of the steps in the analysis as well as in a quite different estimate of the media alternatives resulting from the analysis.

There is also perhaps a need for a general reference source which would list many of the dimensions of stimuli which the various media are capable of presenting. The possible need for this arises from the layman's lack of knowledge of some of the special or unusual capabilities the various media could employ, but which are seldom seen in the normal use of the media. In the absence of such a "taxonomy of stimulus characteristics" and other functions potentially available in each medium, it appeared worthwhile here to simply present in outline form the gist of the intended suggestion for such a reference document.

Sound motion-picture films, for example, have the obvious advantage of a sound track which can be synchronized with video presentation. The sound track cannot only replace the teacher's speaking voice, but can also produce non-verbal sounds a teacher could not produce. In the same fashion, the motion-picture image can present either static or moving portrayals which can consist of "real pictures" or of charts, animated functions, and other scenes which cannot otherwise be seen in nature with the unaided

eye nor otherwise produced in the classroom. Thus microscopic events or theoretical events not otherwise visible can be portrayed by the technique of animation. Special attention-directing arrows or light beams, use of motion, and alternating close shots and long shots can present schematic portrayals in a way not available to a teacher using static charts. On the limiting side, motion pictures are often criticized for the failure to elicit explicit responses on the part of the student. Yet film interruption techniques and "frame freezing" make it possible to pause, slow down, or completely stop the paced presentation in order to wait for student responding, after which feedback may be provided. While it would be difficult and uneconomical to provide self-pacing with a film to the extent it is possible in programmed instruction, the capability which is available in the film medium for eliciting active responding and for providing feedback is seldom utilized except by research people using this medium.

Programed instruction, as another example, offers a convenient way to provide self-paced instruction, and to make convenient the selection of a somewhat different total instructional program for certain individuals. This medium (including teaching machines) also makes convenient provision for elicitation and reinforcement of

explicit responses at whatever interval (step size) the programmer desires, a capability desired for at least some kinds of learning. Yet in classroom applications of this medium, teachers often do everything possible to "keep the class together," thus negating the self-pacing capability this medium offers. Programed instruction, like motion pictures, is subject to many criticisms based on the usual style of programing, while the flexibility which is possible is often overlooked. For example, many programs are justly criticized as being "too verbal"; yet this medium contains all the latitude for pictorial and schematic representation that books and slides make possible, plus the self-pacing and feedback features. At least one "teaching machine" combines the features of programed instruction and motion pictures.

Still slides, accompanied or unaccompanied by a synchronized sound track, have a great potential for kinds of learning which involve chaining and verbal associations. They are relatively inexpensive, and can employ color and self-pacing procedures. They are particularly useful for teaching job-like operations, as they can pause while the student performs a manual act and compares the result of his work with pictorial feedback.

These examples could be continued, but the point is the need for informing the planners of instruction of the frequently

overlooked capabilities which are actually available in the various media, even in their present-day form. This is aside from the new kinds of equipment to become available in the future.

The purpose of the above discussion, in the present context, is to imply that it is worth while, at Step 5 in the analysis procedure, to pause long enough to plan the packaging of instruction in media which will provide the kinds of instructional functions needed for a reasonably-sized sequence of instruction. There is a broader range of alternatives available, for packaging a given sequence of objectives, if one is aware of both the frequently-used and the seldom-used capabilities of the media under consideration. Specifications based on this awareness could result in more effective utilization of media, both in respect to the selection of the media and in respect to how they are to be programed and utilized. One implication of these considerations is that the "new media" greatly overlap in the stimulus situations they potentially can utilize. It is for this reason that the media program is prepared for separate objectives, and then the total media options for each are reviewed in the light of the kind of implicit taxonomy of media potentialities discussed here.

The Influence of the Learner's Prior Knowledge

For reasons previously mentioned, the objectives used for the analysis presented in this chapter required assumption of a minimum of prior knowledge by the target population (five and six year-old children).

The greater the range of concepts and principles which are already in the learner's repertoire, the greater the probability that verbal rather than visual stimuli will evoke recall of relevant knowledge. Also the prompting used by the teacher or other agent of instruction will tend to be highly verbal in this case. These ideas may be examined in the context of programmed instruction. A reading program for first graders would not start with printed words, but with groups of visual patterns to be discriminated. The child would draw a circle around the "different" pattern in each set. Later he shows his ability to discriminate among letters in the same way, then among words and sentences. The typical program for the high school student, regardless of subject matter, is more likely to be highly verbal and abstract, because words are used to help the student select and recall prior concepts for which he possesses verbal labels. The direction can then be given in print: "Using these principles, how could you solve this problem?"

An essential point to be made is that programmed instruction potentially is just as relevant a way to present static pictures, symbols, forms, and diagrams, as it is a way to present printed words. The balanced use of words and pictures could make many overly verbal programs better, but in any case the use of words or pictures should be based on the same rationale when presented by programmed instruction as when presented in film.

During development phases of a new curriculum, it is desirable to give some weight, in the media assignment, to selection of those which lend themselves to an empirical process of tryout, testing, and revision. Developers of programmed instruction have contributed greatly to procedures for accomplishing such curriculum revisions. While application of empirical methods for revision of curriculum materials in any form is theoretically possible, the new media are well designed for this purpose, as the stimulus display is captured, rather than transient (as in what the teacher says), and provision can be made for gathering the criterion data to help spot the displays in need of revision.

In contrast to the advantages of the new media in the respects mentioned in this discussion, the teacher has the advantage of being able to introject comments efficiently. The teacher can easily momentarily draw attention away from a display for the purpose of

providing prompts, feedback, or other instructional events which are apart from the main display of the content of the instruction.

On the other hand, teacher-conducted discussion suffers two important disadvantages: (a) the non-reproducibility of the procedure (in terms of comparing it to another medium or for making empirically-based revisions), and (b) the difficulty in providing the correct feedback to each student in a timely fashion. That is, when students are working alone or in small groups, the teacher cannot be everywhere at once to provide on-the-spot reinforcement, as is possible in some of the automated media. These difficulties, coupled with the difficulty of varying the curriculum for individual children when group instruction is employed, make more attractive the capabilities of automated, individualized instruction.

CHAPTER IV

Further Applications of the Procedure

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In Chapter I it is made clear that the major objective of this project is to advocate the implementation of both a new technical procedure and a new production procedure by which media of instruction would be chosen and developed.

These new procedures ideally would be applied in the initial development of new courses, so that curriculum innovations could be merged with the media choices to be made. Thus, the presently available instructional media in the form of which instruction is available is a matter unrelated to new courses to be designed.

Accordingly, the objectives for the analysis presented in Chapter III were chosen from a newly-designed experimental course which does entail curriculum innovations; this appeared to be a suitable choice for conducting an analysis to illustrate, as nearly as possible, the procedures appropriate in the design of a new course.

In the present chapter, by contrast, a more conventional course was chosen, in order to try out a re-analysis of the present course

content. One reason for this choice was to determine where one might start in attempting to re-design an existing course which is conventional in many respects. Another reason for doing the analysis presented in this chapter was to check upon the statements made in Chapters I and II as to how course objectives should be handled in the proposed analysis procedure. That is, it was decided to try grouping of objectives separately by content and by behavioral outcomes to determine whether the statements previously made about objectives should be modified. If the grouping approach proved possible, in terms of the ability to design media schedules, much less work might be involved in applying the overall procedure.

As will be shown later, this grouping approach was somewhat revealing as to the nature and structure of the course, but it was necessary to revert to analysis of individual objectives in order to design media schedules.

Another reason it appeared of possible value to try a different approach was that the objectives for the selected course were stated in content terms rather than behavioral terms. Since these content items could be grouped in certain logical ways, it was of interest to conduct a test of the assumption stated earlier that particular types of content which appear homogeneous in nature are really

unlike as to type of learning, thus requiring the objective-by-objective analysis said earlier to be needed.

Because of the way the analysis developed, under this grouping approach, indicating the need for media schedules for each individual objective, it was decided to present the complete steps in the procedure for only a few objectives, as the total procedure turned out in such cases to be highly similar to the steps illustrated in Chapter III. One advantage of the present analysis, however, in contrast to that presented in Chapter II, is that the grade level permitted the assumption of reading ability as a pre-requisite, thus avoiding one restriction that was placed upon choice of media in the earlier analysis.

The purpose of this chapter, then, is to indicate how the procedure for the analysis of educational objectives in order to choose media of instruction, as outlined in Chapter II, can be applied generally to courses in science as commonly taught.

The new experimental course, Science -- a process approach, to which the procedure is applied in Chapter III, may be viewed as a rather special and non-conventional series of lessons for elementary school children. It has certain features which make the applicability of the procedure for choosing and utilizing instructional media rather

straightforward. These features should then be present in the process of designing new courses. First, the avowed purpose is to develop the intellectual skills that characterize the ways that scientists think and approach their problems. The objectives are stated in terms of abilities to be developed rather than in terms of factual knowledge to be acquired. So the first step in the procedure, as outlined in Chapter II, is already taken. Second, the behavioral objectives are taught one at a time in a graded series of lessons. It will be noted in Chapter III that each of the objectives is matched to one or more of Gagne's eight types of learning.

Types of learning are differentiated by Gagne on the basis of the major conditions on which they depend. When the type has been identified, many of the major conditions are known. This constitutes the third step. The conditions of learning determine the instructional events on which the choices of media depend.

The analyses in Chapter III leave little doubt that the procedure can be applied successfully to courses which are designed to develop intellectual or manual skills and for which the educational objectives are stated in behavioral terms, and in which the content to be learned is subordinate to the abilities to be acquired. Furthermore, the ability to apply it depends on the degree to which the type or types of learning required by each behavioral objective can be identified,

and the conditions on which learning depends can be specified.

The question now arises as to how well and in what manner the procedure for relating instructional media to educational objectives, as outlined in Chapter II and applied in Chapter III, can be applied to subject-matter courses in science as conventionally organized and taught. The objectives of such courses are usually stated in terms of content to be taught, rather than in terms of specified abilities to be sought. In the background, however, may be certain implicit behavioral objectives. Knowledge of science is seldom taught merely for its own sake. The behaviors sought may be to further independent study, to achieve applications of knowledge to practical problems, and to develop observational and experimental skills. But whatever these ultimate behavioral objectives may be, the teaching emphasis is conventionally upon the mastery of the content. This is indicated by the fact that most conventional quizzes, examinations, and term papers are considered as evidence of the extent to which the subject matter has been mastered.

The first step in applying the procedure to courses that are conventionally organized is to translate the content objectives into behavioral or ability objectives. Unless this can be done, the procedure, as outlined in Chapter II, cannot be successfully applied.

There are two main reasons why the statement of objectives in behavioral terms is an essential first step. One is that media are selected and programed on the basis of the kinds of stimuli they provide, and on the basis of the functions that these stimuli perform in connection with the required learning events. This selection of media cannot be made rationally until the responses required by the learning task have been specified. One of the main purposes of stating objectives behaviorally is to identify the kinds of responses that the learner should be able to make in specifiable situations and in the presence of definable stimuli.

A distinction may be made between responses which are elicited to promote learning, and responses which are elicited in the criterion situation for the purposes of measurement and evaluation of the learning which has taken place. While opinions differ as to the importance of overt responding as a component of the learning process itself, some types of learning and some circumstances in which such responses are especially important are discussed in Chapter I and in Chapter V. However there is no doubt that in other circumstances, such as in concept formation and in problem solving, the desired behavior is often developed in the absence of overt responding; that is, the learning has taken place internally and implicitly upon presentation of appropriate stimuli.

On the other hand, overt responding is useful as a basis for providing feedback to the student, either after the learning takes place, or at the conclusion of a single event in the total instructional procedure, to keep the student's effort directed well. On occasions subsequent to the learning session, test stimuli are presented to evoke responses in order to measure learning, retention, and transfer.

Another useful function of responses made by students during learning is to provide evidence of steps in the instruction which are faulty and need to be revised. In any event, learning by an internal process of implicit responding is usually the goal in mind when selecting instructional stimuli. In this sense, instructional stimuli are always presented for the purpose of resulting in (implicit) responses, and sometimes for evoking overt responses during learning. Whether overt responses are needed or not for a given type of learning, the learning is regarded as consisting of internal activity resulting from the stimuli. (Movement-produced stimuli, in the case of motor learning).

In any event, the behavioral objectives specify the performance expected of the student after the instruction has taken place.

Another reason for stating objectives behaviorally is that it makes easier the second step in the procedure -- that of identifying the

types and conditions of learning that are involved. For example, in Chapter II: it was fairly easy to identify the behavioral objectives as clear cases of concept attainment, or principles learning, or problem solving. Having made these identifications, it was possible to utilize knowledge gained from previous experiments concerning the conditions on which these various types of learning depend. But when objectives are stated in terms of units of subject matter to be mastered, there may be involved several types of learning, and therefore the total conditions needed are interrelated in complex patterns. This involvement complicates the development of media programs, until objectives are cast into behavioral terms. In fact, the whole procedure hinges on the ability to utilize what is known about the conditions on which various types of learning depend. Since most experimental work has been done on the simpler and more homogeneous types of learning, there are faced severe handicaps in applying the procedure to certain instances of the more complex forms which are prevalent in classrooms.

The third step in the procedure is the development of a media program based on the instructional events required by the conditions of learning which are specified by the type or types of learning that are required for the attainment of each behavioral objective. Media are selected on the basis of the kinds of stimuli that they

provide. Stimuli are selected on the basis of the functions that they perform in connection with the learning events. Stimuli perform the functions of motivating, cueing (prompting), reinforcing (confirmation), guiding, and stimulating recall. Any medium of instruction, such as a motion picture, film-strip, programmed lesson, a globe, chart, and verbal instruction by the teacher, may contain a large number of stimuli. Media are the channels through which content is presented, and instructional events are implemented. As indicated in Chapter II, they may be varied along five different dimensions: (a) the sensory modality or channel employed, such as audiovisual; (b) the form of the presentation may vary, as in words, pictures, diagrams, charts, or symbols such as used in music and mathematics; (c) the size, area, or amount of presentation may be varied; verbal content may be presented in words, short sentences, or paragraphs; (d) further variations are involved in order, commonly known as sequencing, and (e) the time of exposure may be varied, as well as the time between exposures.

In view of the fact that media can be varied along each of these dimensions, a very large number of particular stimuli may be selected. When the visual channel is related to the dimension of form, we get several categories of what is seen. When items in this category are related to size, shape, or amount, we get categories of how much is

seen at one time. And so on for the other dimensions. A visual verbal sentence with words in a particular order, exposed for a time as illustrated by frames in a program, defines what is meant by a visual stimulus.

This method for analyzing media into the kinds of stimuli that they provide enables us to choose media in terms of the functions to be performed by stimuli, both in the learning situation and for the criterion tests.

In summary, in order to apply the procedure, outlined in Chapter II, to conventional courses which are organized in terms of content to be learned, drastic changes in the selection and organization of content will need to be made. First, the objectives must be stated in terms of abilities to be acquired. What do we want students to be capable of doing that they could not do previous to the instruction? The criterion tests should be designed to measure the extent to which new abilities have been acquired. Evidence that the subject matter is mastered may not be sufficient. What is desired is evidence of abilities to draw inferences from observations, to apply facts and principles to practical problems, to produce sufficient evidence for a conclusion or judgment, and so on.

Having stated the objective in behavioral terms, the content to be taught, and the way it is taught, should be controlled by these

objectives. The criteria for the selection of content should be not so much what students should know but rather what they should be able to do.

The criteria for the selection of media of presentation are the learning activities or events that are indicated by the conditions of learning on which the acquisition of specific abilities is known to depend.

Application to a Programed Course in Geography and Geology

This course was prepared by Dr. Vincent N. Campbell and research assistants in collaboration with a number of teachers of sciences in local schools near Palo Alto, California (Campbell, et al., 1964). It was designed for an experiment on program-directed study versus self-directed study. Twelve units of instructional materials were programed: one on water, two on air, one on geology, three on map and globe reading, one on earth-sun relationships, one on doldrums, one on deserts, one on horse latitudes, and one on trade winds. These units comprise most of the factual materials that are commonly taught in elementary courses on geography and geology. The materials were selected mostly from books written on related topics, supplemented with filmstrips and a few motion pictures.

For each of the units a list of content objectives was prepared. For the unit on water there are 19 such small chunks of subject-matter, stated usually in a sentence or a short paragraph. Each content objective is followed with a program consisting of from 10 to 20 frames. At the end of each program is a practice criterion test of two or three items. At the end of each unit is a criterion test of several items covering the content of the unit.

The entire course occupied one class period a day for an entire school year. About three-quarters of the time was devoted to individualized instruction and one-quarter to group instruction. The course is conventional only in the sense that it is designed to teach a body of subject matter, but unconventional in the way the materials are presented -- i.e., programed for individualized instruction.

It should be easier to apply the procedure for relating media to objectives when the subject matter has been programed. Programing is a way of specifying learning tasks in great detail and in stimulus-response terms. The criteria employed for the selection of prompts and feedback terms are in some respects the same as those for matching media to objectives. There may be, however, important differences between programing for the purpose of teaching content, and programing for the purpose of developing abilities.

The Construction of Behavioral Objectives and Media Programs

When behavioral objectives are not provided with the course, as in the present instance, they may be specified either by raising and answering the basic question as to why teach geography at all rather than spending the time on some other subject or subjects, or by inferring them from the criterion tests, or from an analysis of the behaviors to which the content taught may contribute, or by all three of these procedures.

If educators who advocate the teaching of an elementary course in geography and geology are asked for reasons why such a course should be taught at this grade level, they are likely to give a number of reasons. One is that such a course contributes to abilities which constitute an important part of the education of youth. If the criterion tests designed to give evidence that a body of content has been learned are examined, it will be found that some of the items also give evidence of the achievement of certain abilities.

The long lists of content objectives that are specified by the programmed lesson^{on} geography may be classified into a relatively few categories, each of which has behavioral implications. For example, the content objectives of this programmed course may be classified into the following broad categories: (a) knowledge of the

terminology by which the facts, principles and explanations taught are communicated (the lessons are accompanied by a glossary of technical terms to be learned); (b) knowledge of facts and principles of natural phenomena for water, air, earth and earth-sun relationships; (c) concepts and principles by which these phenomena are explained; (d) applications of facts and principles to practical problems, and (e) knowledge of the scientific method and how it is employed.

The acquisition of these categories of knowledge may be considered as contributions to the behavioral outcomes which constitute the reasons for teaching an elementary course in geography and geology in elementary schools. Three or four broad areas of abilities may be recognized: (a) the ability to communicate; this ability ^{includes} ~~includes~~ the ability to understand the meaning of scientific communications, on the one hand, and to use the terminology of a science correctly in communicating with other persons; (b) the ability to relate variations in natural phenomena to trade, commerce, and other aspects of organized social life, and how ways of living are determined by physical environments; (c) the ability to explain natural phenomena in terms of basic concepts; (d) the ability to draw inferences from observations, and (e) the ability to apply facts, concepts and explanations to practical problems.

As indicated in Chapters II and III, in the application of the procedure for relating instructional media to objectives, it is necessary to state the behavioral objectives in terms of types of responses to be made in specifiable situations and in the presence of identifiable stimuli. This means that objectives should be stated in stimulus-response terms.

Next presented are some illustrations of how content objectives can be viewed in relation to specific behavioral objectives.

Class names. Among the terms employed in the programmed lesson on geography are several class names such as solids, liquids, gases; oceans and continents; mountains, plains, plateaus, deserts, and glaciers; faults, folds and uplifts; doldrums, horse latitudes, and trade winds.

The specific criterion performances to be acquired are: (a) to respond with a correct example when a class name is given as the stimulus term, and the student is directed to write or pronounce an example; (b) to respond with the correct class name when an example is given as the stimulus term; (c) to sort a mixed list of examples into the class to which each belongs; (d) for a list in which the number of instances that constitutes a class is limited, to be able to name all of them; (e) the ability to state the distinguishing features of a class -- for example, to state the difference

between doldrums and horse latitudes.

When grouped in the above manner, several behavioral objectives are thus seen for each content element labeled "class name". While in general most of the class names, stated as content elements, appear to require concept formation, when a given content term is examined in its behavioral aspects, several objectives are derived, representing different kinds of learning.

For example, consider the terms liquid and gas, in light of several possible behavioral objectives:

1. Be able to state the difference between a liquid and a gas in terms of molecular action. This requires learning of the principle which states the relationship of speed of movement of molecules to form of matter. Learning this principle involves the prerequisite concepts of speed, movement, molecule, and form of matter, and their chaining into a verbal principle. Once learned, the principle is recallable for use in solving more complex problems. Thus the conditions for concept formation and principle learning are to be arranged for in the selection of media of instruction.

2. Be able to classify examples as gas or liquid. This could either be taught by requiring memorization of each specific example of these two forms of matter (verbal association: helium-gas), or by learning the characteristics of each form of matter (principle:

a gas is invisible), and by matching these characteristics (problem solving) to a description of a given example of a gas.

3. Be able to name the characteristics of gases. This requires the conditions for forming chains of verbal associations.

It may be seen from the above that the process of beginning with attempts to group elements of instruction by content categories is not exceedingly helpful, since it is next necessary to identify the type(s) of behavior desired in respect to each content item, as described in Chapter II. The construction of the media program could only then be pressed forward. About the only advantage which accrues from the content grouping pertains to decisions as to sequencing of instruction. Even so, it is the inferred capabilities that are sequenced in order to take advantage of transfer, not the content elements or classes. So the need to begin with the available content items, because that was the form in which the course was encountered, even though they can be grouped into classes, still requires the pairing of the behavioral and the content elements in specifying objectives in the form needed for construction of media programs. Here is the advantage of the more direct procedure of stating behavioral objectives at the outset.

Globe nomenclature. In the programmed lessons on geography, three units were devoted to globe reading. Several kinds of globes

were used: regular, plastic-transparent, slate and rubber.

The specific abilities to be achieved and tested were:

1. To point to lines on the globe that represent the equator, latitudes of cancer, capricorn, arctic and antarctic circles, Prime Meridian, etc.
2. To draw lines on a blank slate globe to represent the equator, latitudes, and longitudes.
3. To calculate distances north and south from the equator in terms of degrees of latitude, and the same from the Prime Meridian in terms of degrees of longitude.
4. To draw on a slate globe lines that represent boundaries of oceans and continents.

Examining each of the above objectives, in turn, makes the following observations possible; these observations are numbered to correspond to the numbered objectives above.

1. This objective can be conceived of as requiring multiple discrimination among previously learned principles. The principles could be taught as verbal chains (definitions) such as, "The arctic circle is a line drawn to connect all points on the earth's surface falling approximately $23\frac{1}{2}$ degrees south from the north pole." Passing this test (pointing correctly to the arctic circle on a globe) could, however, be based on the simple association of arctic circle with

north pole, provided that north pole is discriminated from other points on the surface of the earth. While the individual principles could be learned either by verbal definitions or by names associated with lines on a globe, the later making of consistent discriminations among them is enhanced by employing distinctive cues while each is learned, and by overlearning one before introducing the next, in order to avoid interference. This objective, then, could be reached without learning the definitions of the various lines. Once learned, the student could induce verbal definitions as an example of problem-solving. The particular media program then, would involve, as a minimum, the pairing of "arctic circle" with that line drawn on a globe, and sufficient practice to promote overlearning before introducing other lines. This association could employ the distinctive cue as a bridging device: "arctic circle - north pole - this line". The media could be words and lines on a globe, or any pictorial representation of this. The feedback to each response could be automated, teacher administered, or self-administered by reference to a guide. The instruction for this "pointing" objective would be different, perhaps, if verbal definitions were also to be required.

2. Being able to draw the lines on a globe when given the names of the line would not require instruction, if objective number 1, above, is first learned. This could then become a test item to measure

generalization from the previous objective.

3. Calculation of distances in terms of degrees requires the conditions of learning of principles unless it is desired that this be induced by discovery, in which case the conditions for problem-solving would apply.

It is again apparent, then, that several types of learning are required for the objectives subsumed under "globe nomenclature," and that media schedules would vary accordingly.

Time and place relationship. Related to globe reading are a number of specific abilities such as:

1. To identify time zones and calculate differences in time between any two given places.
2. To tell the relative lengths of days and nights at any place on the earth during a given month.
3. Times and places where rainfall is heaviest and lightest.
4. Places where earthquakes are most likely to occur.
5. Places where there is little wind and much rain.
6. Places where deserts are found; where glaciers are found; where icebergs appear.

Again, no single type of learning is represented by the subject-matter heading. Without presenting an analysis of the instructional events which would be used in the media schedules, the following

designations as to type of learning may be made for the above numbered objectives:

1. Time zones - verbal association. Calculating time differences by zones - problem solving.
2. Relative lengths of day and night - principle learning.
3. Rainfall - principle learning.
4. Earthquake - principle learning.
5. Wind and rain - principle learning.
6. Deserts, etc. - principle learning.

Responding consistently and correctly on these objectives is not simply a function of adequacy of the initial learning, but also requires selection and recall of the correct concepts. These latter functions are enhanced by use of distinctive cues, overlearning, and practice in discriminating among successive principles or concepts as they are being learned. The instructional materials then would make frequent use of such cues as, "In contrast to the principles for predicting the location of deserts, heavy rainfall is found in regions in which -----."

Cause and effect relationships. Ability to relate conditions to the occurrence of natural phenomena. Some of the specific abilities sought are:

1. Ability to state the conditions under which rain, hail, sleet, snow, dew, frost, etc., will occur.

2. To describe the conditions in the crust of the earth that cause earthquakes.

3. The ability to predict consequences when certain conditions are stated; e.g., if warm air blows over cold ground, what will the result be.....? What happens to all matter when it is heated?

These objectives reduce primarily to the learning of principles, and to the recall of the learned principles in rather simple problem-solving situations. In some instances, the apparent problem-solving (test) situations could be reacted to correctly through stimulus generalization, e.g., responding to new words having a familiar meaning.

Ability to draw inferences from observations. This ability is closely related to responding to problems involving cause-effect relationships by use of learned principles. Ability to draw inference from observation is perhaps one of the most important abilities to be achieved from the study of sciences. It is presumably a generalized ability that is enhanced by both direct instruction and by practice on a variety of examples. It is undoubtedly an aspect of performance which is heavily influenced by intelligence as well as by experience and education. Some of the specifics are the following:

1. What conclusions could be drawn from the fact that the bones of a whale have been found in the Sahara Desert?

2. From the observation that the lands of the midnight sun

are about $23\frac{1}{2}$ degrees from each pole, what conclusion can be drawn in regard to the tilt of the earth's axis?

3. From the observation that the sun always rises in the east and sets in the west, what conclusion is drawn in regard to the direction of its rotation?

4. By counting the rings on the stump of a tree, and noting the spaces between them, what conclusions can be drawn as to the age of the tree and the annual rainfall?

5. What conclusion can be drawn from the observation of large smooth boulders lying on hillsides and in other places?

These objectives represent problem-solving activities. As implied at the opening of this section, some of these test questions could probably be answered by many students on the basis of their general intelligence and the relevant principles which they have been taught. However, for the sake of illustrating a media program for an objective in problem solving, the following analysis is presented, on the assumption that some students could not solve the problem without some instruction or coaching.

Analysis of Objective No. 1

Step 1.

Objective: How could you explain the fact that the bones of a

whale have been found in the Sahara Desert?

Step 2.

Type of learning: Problem solving.

Step 3.

Conditions of learning:

- (a) Learner must know the nature of the goal sought before he arrives at the specific answer.
- (b) Learner must recall (or be taught) relevant principles.
- (c) Learner must combine relevant principles in a fashion to solve the problem (he may have to form hypotheses about principles he does not know).
- (d) Learner may exhibit trial and error in the effort to select relevant information and use it successfully.
- (e) Once solved, such solutions are remarkably resistant to forgetting; repetition of the same problem not very helpful.
- (f) The total process requires use of many past learning experiences originally achieved by subordinate types of learning (discrimination, chaining, concepts, etc.).
- (g) Learner often can supply his own feedback; e.g., he recognizes a correct solution when he achieves it. Reward for solution may therefore bring motivating and

reinforcement conditions, but not feedback (new information).

Media Program

Instructional Event

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|--|--|
| 1. Inform learner of performance required | 1. "Your answer must explain how this fact could come about, in terms of other information that can be substantiated." |
| 2. Stimulate recall of component concepts or principles. (Not all of these prompts should be necessary.) | 2. "Do whales fly, swim, or walk?" "Do they live on land or in water?" "Does a lake, river, or ocean ever dry up?" "Does the earth's surface change in form and nature over long periods of time?" "Have whales existed long?" |
| 3. Provide verbal guidance | 3. "Can you put all your answers together and give an answer to the question?" |
| 4. Student response | 4. "The Sahara Desert could once have been the bed of a sea or ocean." |

Step 4.

Media Alternatives. (This step, it may be recalled from Chapter III, may be considered for single objectives or for a set of objectives. In normal practice it would be for a set of objectives. For present purposes it is taken up for a single objective, and discussed as though it were the final choice of media, represented normally by Step 5).

Factors in decision:

1. There is no requirement for pictures. The student can either read or hear the verbal statements listed under "medium".
2. The student will therefore first "mentally" arrive at an answer, and then speak or write it to receive evaluation.
3. The student may need feedback to responses he makes to the verbal prompts supplied. That is, his answers to the attempts to stimulate recall of relevant information may need to be corrected.
4. Some students will need more of the prompts than others before reaching a solution.

Media Alternatives.

1. Programed instruction can supply these conditions. The student is allowed to record and check his answers at any time. Thus he can skip (bypass) unneeded steps in the instruction. He is required to write his answer before viewing feedback to discourage random guessing.
2. A teacher or a series of slides or audio (taped) presentations can also provide the conditions. (For young children who would require even heavier prompting, a motion picture sequence of evaporation and eventual disappearance of a body of water could provide the introduction of the problems.)

Media Selection.

1. Programed instruction sequence for older children.
2. Movie followed by audio-tape program for young children.
3. Teacher for individual tutoring situation.

Solving problems in quantitative relationships. Natural

phenomena vary in respect to many different but interrelated dimensions, such as size, shape, weight, speed, density, temperature, and frequency of occurrence. Comparisons are made in terms of larger than, faster than, thicker, drier, hotter, colder, and so on. Solving problems by use of principles and concepts could involve test questions such as the following:

1. Arctic winters are (colder or warmer) than antarctic winters.
2. Air pressure at the poles is (greater or less than) at the equator.
3. Hot air will absorb (more or less) water than cold air.
4. There is (more or less) vegetation on the leeward sides than on the windward sides of mountains.

Answers to these questions could of course be taught in rote fashion, but such statements would be highly subject to forgetting, and are of greater value as questions to stimulate recall and use of relevant principles.

Functional relationships. These relationships are sometimes called empirical laws. They may be expressed mathematically as $y=f(X)$. As Y is increased, decreased, or otherwise varied, systematically related changes occur in X. The ability to express these relationships in mathematical terms is beyond the levels of ability of 5th and 6th grade children. However, they can acquire the ability to predict the direction of change in X when Y is varied in a specified direction. Examples include the following:

1. The drier the air the (more or less?) water it will absorb.
2. The hotter the air the (faster or slower?) it will rise.
3. The higher the air above the earth the (thicker or thinner?) it becomes.

The above examples, when in declarative form, are principles to be learned. When stated as questions, they are the problems posed at the beginning of instruction in problem solving. When used as test questions, they may indicate transfer (improvement in problem-solving ability) due to prior instruction in use of principles for the purpose of solving problems.

Solving problems involving explanatory concepts and explanations. The abilities sought are those of explaining

observable phenomena in terms of basic concepts. Some examples of phenomena to be explained are:

1. Why do metals expand when heated?
2. Why is it that clothes on a line will dry faster on a warm windy day, than on a cool calm day?
3. Why does hot air rise?
4. Why is it that Arctic winters are warmer than Antarctic winters?
5. Why are days very hot and nights very cool in deserts?
6. Why are most deserts located in or near horse latitudes?

Explanations may be graded in difficulty. It is easier to explain why metals expand when heated, than to explain why Arctic winters are warmer than Antarctic winters. An explanation is basically an assembly and ordering of relevant facts. The greater the number of facts to be known, recalled, and ordered, the more difficult the explanation. Desert days are hot mainly because (a) it seldom rains, and (b) desert sands are dry and reflect the heat of the sun into the air. Nights in the desert are cool because (a) the hot daytime air rises, and (b) deserts are in regions where cooler dry air is falling.

The solution to the above example (being able to explain why days are hot and nights cold in deserts) rests upon the selection of the correct array of principles previously learned, and putting them together to solve the problem (give the explanation).

It would clearly be possible to deliberately teach the four principles identified above as a unit in order to facilitate the student's solution to the problem because of this overall sequence prompt so provided. Doing this would remove the need for the student to search from among all principles he has learned in order to select the ones needed. Teaching the principles in this particular order thus might facilitate solution of this problem, but at the same time it would make more difficult the solution of other problems requiring some of these same principles. It is for this reason (e.g., no one sequence will make it easy to solve all problems in which these principles are useful) that the student is encouraged to practice problem solving. Stated differently, instruction can be designed in a given sequence to make learning of some objectives easy (not require problem solving), but this same sequence will mean that other uses of the learning will have to require problem solving. Thus the direct teaching to the student of the solution to all problems the teacher has already solved is impossible economically, and undesirable from the point of view of preparing the student to solve problems in the future which his teachers have not encountered or solved. While the role of practice in improving general problem-solving ability is not very clear, the great superiority of the capability of human beings appears to rest

in the use of language and symbols to manipulate, combine, search, and recall principles which can be used in new combinations to solve new problems.

Following from the above, it appears a reasonable procedure to design instruction in such a way that principles are sequenced so as to have two possible values: (a) to teach some problem solutions thereby, and (b) to make the learned principles available to the student as raw materials for solving different problems.

To illustrate the above point, an analysis is presented which begins with a statement of a general behavioral objective to serve as an end goal. The student would thus be informed that one purpose of the entire sequence is to become able to give the total explanation called for at the conclusion of the entire sequence. Subordinate objectives, requiring learning of concepts and principles needed to reach the end goal, are also stated. Some of these same concepts and principles, once learned, could also be used to solve other problems.

The form in which the following analysis is cast is somewhat different from the form used in previous analyses presented, in order to illustrate certain points.

Sequence objective: Be able to explain how changes in seasons of the year and day and night are caused.

Subordinate objectives:

1. Explain why night and day occur in 24-hour periods, rather than some other period.
2. Explain why daylight hours are longer at some times of the year than at others.
3. Explain time zones in terms of earth-sun relationships.
4. Explain relationship of the $23\frac{1}{2}$ degree tilt in the axis of the earth and 24 hours of daylight in a certain area of the surface of the earth.

Comment: The type of learning required to perform the total sequence objective and the subordinate objectives is problem-solving. Steps in the instruction require concept learning and principle learning. The desired stimuli for initial presentation of each concept and principle requires motion-picture sequences. However, recall and practice in use of the principles are to be accomplished by printed drawings and verbal statements and questions (e.g., programed instruction). The initial use of motion pictures establishes images which can later be reinstated by static display. Since the terms "rotation" and "revolution" are highly confusable (so much so that many students do not even see that they are different when printed materials are used as initial instruction stimuli), strong prompts (mnemonic devices) are used to mediate the correct responses in recall and practice sessions.

Principle: The earth rotates on its axis once every 24 hours.

Media Program

Instructional Event

Medium

(1) Inform learner of performance required.

(1) Narration: This picture enables you to explain how night and day are caused.

(2) Present stimulus.

(2) Video: Model of earth rotating on its axis, with a light source (representing the sun); narration calls attention to light and dark areas on the earth.

(3) Present prompt for concept "rotation."

(3) Sequence showing spinning top. The printed display Top-Spin-Rotation is on screen while narrator and arrows point to the "t" in top and the two "t's" in rotation. "Rotation means spinning around on an axis like a top." (Shot of earth and top spinning.)

(4) Evaluation.

(4) Programed instruction sequence (drawings with arrows to represent movements just seen in the film, as the test stimulus); responses are "rotation," "top," "earth," "spinning," and "night and day."

Principle: The sun rises in the east because the earth rotates toward the east.

Media Program

Instructional Event

Medium

(1) Inform learner of performance required.

(1) This picture will enable you to explain sunrise, sunset, and time zones.

(2) Present stimulus.

(2) Motion picture of earth with cities labeled. Rotation of earth brings sunrise first to New York, then to Denver, then to San Francisco. Narration and arrows illustrate sunrise, noon, sunset, time zones.

(3) Present prompt.

(3) Movie sequence of the memory device illustrating "Rule of the right hand," which mediates recall of rotation toward the east.

(4) Appraisal.

(4) Programed instruction with drawings of other cities on the globe. Responses are "rotates toward east;" correct response to order of sunrises in various cities; correct responses (hours) for time zones.

(5) Generalizing experience

(5) Explain "one day of time" in terms of the earth, sun, rotation, and axis.

Principle: One year is one revolution of the earth about the sun.

Media Program

Instructional Event

Medium

(1) Inform learner of goal.

(1) After this lesson you can explain how seasons are made.

(2) Stimulate recall.

(2) "Define rotation; axis; day."

(3) Present stimulus.

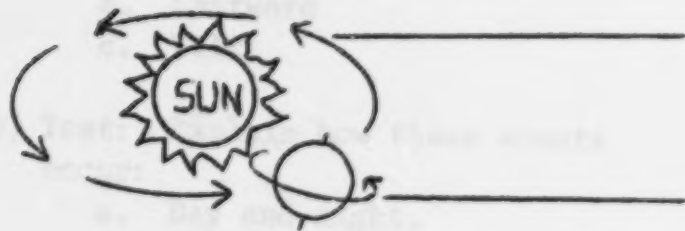
(3) Motion picture of earth re-volving around the sun as it rotates on its axis. Narration and arrows in close-up shots in sequence, emphasize rotation of earth on axis, then revolution. Slow and fast motion sequences relate one rotation with one day, and one revolution with one year.

(4) Present discrimination of two terms.

(4) Narration: "Here are the two 'ts' in rotation of the earth about the axis, like a top" (arrow); "but here is the revolution" (picture).

(5) Stimulate recall.

(5) Drawing showing:



Write the correct word next to the two arrows.

- | | |
|---|---|
| <p>(6) Present new stimulus.</p> <p>(7) Present prompt.</p> <p>(8) Present new stimulus.</p> <p>(9) Stimulate recall of relevant principles and concepts.</p> <p>(10) Evaluation.</p> | <p>(6) Motion picture with arrow to tilted axis. Narration of significance of tilt in relation to area on which sun shines as earth rotates, and changes as earth revolves. Illustration of seasons.</p> <p>(7) Film showing both the direction of rotation and revolution; effect of tilt; cause of seasons. Require response of drawing arrows on drawings after seeing film.</p> <p>(8) Movie showing relation of degree of tilt with arctic circle measured in degrees from north pole. Narration of relationship while earth makes one rotation about sun.</p> <p>(9) Instructions on a test:
 "Recall meaning and the resulting effect upon day and night and the seasons, of the following:"
 a. Rotation
 b. Revolution
 c. Eastward
 d. Tilt</p> <p>(10) Test: Explain how these events occur:
 a. Day and night.
 b. Winter and summer.
 c. Sunrise and sunset.
 d. "Land of midnight sun".
 e. Time zones.</p> |
|---|---|

Summary of Sequence Strategy

This sequence objective required learning of several concepts and principles, and recall of them in such a fashion as to solve problems consisting of explanations.

The sequence of instruction was designed to establish principles explaining "one day" before introducing principles about "one year" and "seasons". The first principle relates to the concepts of rotation and axis. The second one relates to tilted axis, and revolution. Since rotation and revolution are highly confusable, prompts were taught rather than merely used to evoke responses.

Single concepts and principles in the overall sequence, used to reach the objective, explain "night and day" and "seasons", will also be useful for solving other problems listed in this chapter.

Experience shows that young students do not interpret still drawings (such as rotation and revolution), as the artist often intends. Thus the first, critical, stimulus presentation should be either a film (as specified here), or a globe demonstrated in relation to an object standing for the sun. Teachers who have first learned these relationships incorrectly often have trouble later in giving a correct demonstration. A light source is needed for best results. So a motion-picture film or a demonstration with moving, 3-dimensional models is indicated.

When the correct initial stimuli have been given, then the child can grasp the significance of static drawings used for practice, recall, prompting, and evaluation.

CHAPTER V

SELECTIVE REVIEW OF LITERATURE ON AUDIOVISUAL MEDIA OF INSTRUCTION

Peggie L. Campeau

Purpose and Scope of Review

Purpose

The purpose of this chapter is three-fold:

1. To review experimental research in light of the objectives of this project: i.e., the selection and use of appropriate audiovisual media for achieving given learning requirements.
2. To show the limitations of these studies by pointing out important questions which have been left unanswered -- questions which would have to have been resolved in order to have made the literature on media research more directly useful in terms of the present project.
3. To suggest types of media research which are needed to supply answers to these unanswered questions -- research, which if completed, could yet be useful in developing improvements in the procedures recommended in this report as a whole.

Scope of the Literature Review

In focusing the review on experimental research relevant to the selection and use of appropriate media of instruction, comparative effectiveness studies, utilization studies, and basic studies were the categories of research judged to be of the most potential usefulness in helping to determine which media to choose for a given instructional package and how to use each medium in the package most effectively:

1. Comparative effectiveness studies. Some studies compare the relative amounts of learning which result from instruction by a given medium as compared to instruction by conventional methods. (Conventional methods can include other media in addition to textbooks and teacher presentations.) Other comparative effectiveness studies pit one medium against another medium (e.g., instructional film against instructional TV, programmed instruction against instructional film, a combination of filmstrips and soundtrack against still pictures with printed captions, and so on).

2. Utilization studies. These studies go a step farther by discovering how (but not why) a given medium teaches best. Typically, such studies compare one method of using a medium against another method of using that medium to determine

which utilization produces the most learning (e.g., teacher introduction plus instructional film versus instructional film plus teacher review).

3. Basic studies. This label is used here as a catch-all for the more fine-grained and highly analytical studies which seek to explore media and learner variables which may be related to achievement. For example, what characteristics of the learner determine how effective instruction by a given medium will be for him? What behavioral processes or learning conditions must be provided in order to learn a given instructional objective most effectively by a given medium? What particular characteristics of a given medium render it most effective for achieving given learning requirements? Unfortunately, most of the media reviewed here (with the exception of programmed instruction) have not as yet been subjected to much of this kind of analysis.

Exclusions. Several very large bodies of research have been omitted from consideration -- some, because they were judged not directly relevant to the focus of the review (i.e., the selection and use of media); others, simply to reduce the overwhelming volume of media research to workable proportions.

Specifically, the following bodies of research have been

excluded from this review:

1. Production studies. Such studies determine techniques of production which enhance the instructional effectiveness of media. In terms of the discussion in Chapter I, this is "sharpening" research and is not research relevant to the choice and use of media.

2. Military research. An arbitrary decision was made to restrict the review of media research as much as possible to classroom studies conducted in non-military educational institutions from the elementary school through the university in a wide variety of school subjects.

3. Attitudinal and motivational research. Effects of instruction by a given medium on the learner's attitudes and motivation were arbitrarily eliminated in favor of restricting the review to assessing the instructional effectiveness of media (i.e., the effectiveness of media for promoting learning as opposed to changing attitudes and interests relating to the content of the instruction).

4. Media-preference research. Also excluded were studies which report students' preferences for instruction by various media.

Shortcomings of the Literature

In Chapter I there appears a discussion of several reasons why

existing audiovisual research could not be used to help develop and implement an analytic procedure for selecting and using media, such as the procedures outlined in Chapters II, III, and IV. As background for the literature review to follow, it will be useful to outline some of the more general shortcomings which characterize audiovisual research.

Admittedly, the quality of such experimental studies is extremely uneven, judged on a number of criteria:

1. Most comparative effectiveness studies do not provide evidence that steps were taken to insure equal coverage and emphasis on content by the media being compared. The inherent limitations of comparative effectiveness studies were noted by Lumsdaine and May (1965) and by Lumsdaine (1963).
2. In the great majority of comparative effectiveness studies, the experimental treatment actually used an audiovisual medium in combination with some amount (usually unspecified) of instruction by the teacher. Yet no systematic analyses are made of the relative contributions of media and teacher instruction to learning by the experimental group.
3. Many of the studies reviewed here took into account the effect of ability level of students on performance. However, some did not control for differences in prior knowledge of the

subject matter so that it was impossible to determine whether the greater effectiveness of one method over another was due to the method itself, or to the fact that students in an experimental group knew more about the topic initially than did control students.

4. Relatively few investigators attempted to equate in some way differences in time among various instructional methods being compared. (Quite frequently, the most successful method took longer than alternative methods.)

5. Almost without exception, intact classes were used rather than selecting individuals by random sampling. The drawbacks of this procedure are cited at several points in Gage (1963) and by Greenhill, (1964).

6. Sample sizes (number of students participating in the experiments) varied considerably, ranging from students in a single classroom to an entire school system. Effects of sample size on the reliability of experimental results are discussed in most standard statistics textbooks (see also Lumsdaine and May, 1965).

7. In the studies reviewed here, the relative effectiveness of various media is usually measured by test performance on instruments prepared especially for a given study by the investigator. Only rarely, however, does an investigator provide evidence

as to the reliability and validity of his criterion tests. With the particularly high incidence of no-significant-differences findings in audiovisual research, one wonders whether these specially constructed tests were always powerful enough to reveal differences which in fact did exist between methods (see Lumsdaine and May, 1965).

8. Especially in film research, the typical comparison is between conventional methods and instruction by some on-the-shelf item (i.e., a film that already has been produced and released for classroom use). Perhaps there would be more instances of significant differences in favor of an audiovisual medium if some systematic analysis of subject matter to be taught had been used to guide film or other media producers in tailoring their presentation to the specific requirements of the lesson.

9. In most studies the teacher plays a prominent role in instructing students, frequently in both control and experimental groups. Just as there may be pronounced differences in instructional effectiveness from one medium to another, so there are bound to be differences in the effectiveness of one teacher as compared to another. Although it is certainly conceivable (and sometimes has been demonstrated) that differences between teachers can reliably affect the amount learned by students

(over and above learning accounted for by effects of treatment, ability, prior knowledge, sex, etc.), very few studies have taken adequate steps to control for the teacher variable. Programed instruction, being essentially self-instructional in nature, however, is a noteworthy exception in that in the great majority of studies using this medium it has been possible to completely eliminate instruction by the teacher in experimental groups, thereby providing a relatively clean comparison between programed and conventional instruction. (Even so, the conventional instruction is hard to define or replicate.)

Other qualitative inconsistencies among the research reviewed could be enumerated, but the several items already noted serve as an indication that studies vary considerably in terms of adequacy of experimental design and controls. Adding to this the fact that the conscientious investigator typically cautions against generalizing results beyond the particular task, the particular audio-visual aids, the particular students, and the particular teachers used in his study, we are left with research evidence that can be interpreted in only very limited ways. A basic reason for such appropriate cautions against over-generalization of the findings is that neither the characteristics of the learners nor the type of learning involved have been described adequately to show what

generalizations might be justified.

No attempt has been made in the review which follows, however, to criticize specific research studies on any of these grounds. This is because quite a different dilemma became apparent when we attempted to use this literature for guidance in designing a procedure for selecting media. In terms of the objectives of the present project, the research simply had not asked the right questions. Therefore, studies in the sections to follow are simply cited as examples of media research which we had hoped would be directly relevant to this project. Also, the review will provide background for a discussion of limitations of present research and suggestions for future research which will be presented at the close of this chapter.

Television

Comparative Effectiveness Studies

Studies comparing the effectiveness of televised instruction with face-to-face (conventional) instruction by a teacher represent the largest category of comparative effectiveness studies. The bulk of these studies show no significant differences between the achievement of students taught over TV and students taught in the

conventional manner (Allen, 1959, 1960). However, a few studies reveal significant differences in favor of televised instruction, and others find significant differences in favor of conventional instruction. Summarized first are studies in which no differences were demonstrated.

At the university level, no reliable differences in the instructional effectiveness of TV as compared to conventional instruction were obtained in teaching Spanish verbs (Bundy, 1960), fundamental mathematics (Alexander, 1961), general physics (Bailey, 1958), psychology (Carpenter and Greenhill, 1958; Dreher and Beatty, 1958; Durham, 1958), chemistry (Carpenter and Greenhill, 1958), sociology (Davies, Gross, and Short, 1958; Carpenter and Greenhill, 1958), calculus (Dyer-Bennett, et al., 1958), meteorology (Carpenter and Greenhill, 1958), slide rule operation (Gordon, Nordquist, and Enger, 1959), advertising (Kumata, 1960b), political science (Erickson and Chausow, 1960), English (Erickson and Chausow, 1960), humanities (Erickson and Chausow, 1960), and music appreciation (Carpenter and Greenhill, 1958).

At the high school level, students taught over TV achieved as much as students taught conventionally in mathematics (Berger, 1962; Geddes, 1961), slide rule operation (Anderson and VanderMeer, 1954),

science (Champa, 1958; Herminhaus, 1957), English composition (Herminhaus, 1957), biology (Jacobs and Bollenbacher, 1960), math computation -- as opposed to problem solving (Jacobs, Bollenbacher, and Keiffer, 1961), and American government (Jantzen, 1963).

In the elementary schools, no reliable differences were shown between televised and conventional instruction in teaching scientific reasoning (Dietmeier, 1961), sixth-grade science (Enders, 1960), selected sounds (Gordon, undated), and reading, arithmetic, and French (Himmler, 1957). Furthermore, TV frequently has been found equally as effective as conventional instruction for promoting long-term retention of learned material (Allen, 1959; Kumata, 1960a; Benschoter and Charles, 1957; Curry, 1960). Retention tests were administered at intervals which ranged from two weeks to three years after original learning.

Occasionally, significant differences in achievement have been found to favor either televised instruction or conventional instruction. For example, at the university level, Pasewark (1956) demonstrated that instruction by TV produced significantly more learning than conventional instruction in teaching typewriting. On the other hand, conventional instruction was favored to a significant degree in advertising (Kumata, 1960b), and in humanities

(Erickson and Chausow, 1960). For junior and senior high school students, televised instruction was shown to be significantly more effective than conventional instruction for chemistry -- Negro students (University of Alabama, 1961), American history -- white students (Johnson and Harty, 1960), and one out of three math lessons (Berger, 1962). However, significant differences were obtained in favor of conventional instruction for chemistry -- white students (University of Alabama, 1961), geometry (Johnson and Harty, 1960), and two out of three math lessons (Berger, 1962). Similarly, in elementary schools, significant differences favored televised instruction for science -- white students (Johnson and Harty, 1960), science information -- as opposed to scientific reasoning (Dietmeier, 1961), science (Enders, 1960), and remedial speech (Gordon, 1960), while conventional instruction produced significantly greater learning in elementary science (Pflieger, undated).

Differences in effectiveness between instruction by TV and by conventional methods have sometimes been found to vary with ability level. High-ability students learned significantly more by TV than by conventional methods in psychology (Dreher and Beatty, 1958) and in science (Jacobs and Bollenbacher, 1959); on the other hand, conventional methods of instruction were most effective for low-

ability students in science (Curry, 1959, 1960; Jacobs and Bollenbacher, 1959). However, conventional instruction was significantly better than TV for high-ability learners in English composition (Buckler, 1958) and mathematics (Curry, 1959), while TV was significantly better than conventional instruction for low-ability learners in economics and psychology (Dreher and Beatty, 1958) and math problem solving (Jacobs, Bollenbacher, and Keiffer, 1961).

Relatively few studies have compared the effectiveness of instruction by TV with instruction by a medium other than a teacher, or by a combination of media. An example is the study by Barrow and Westley (1959) who found that televised programs on current events produced significantly greater learning of factual information than comparable programs presented by radio, even though the same experienced script writer prepared TV and radio versions of the lessons "to utilize the full potentialities of both media" with relatively equal emphasis on various aspects of content.

Utilization Studies

The studies in this category suggest methods for using TV most effectively, both as a sole means of instruction and in combination with other media. Illustrative studies include the following.

Bryan (1961) supplemented instructional TV in high school chemistry and physics with (a) correspondence study, (b) a teacher trainee who personally tutored the learner, and (c) both correspondence study and tutoring. He reports that although comparisons among methods were inconclusive for the physics subject matter, analysis of the data from the chemistry groups revealed a significant difference in favor of supplementing TV with correspondence study and a tutor as compared to supplementing TV with either correspondence study or a tutor alone.

Garry (1960) used ninety classes of fifth graders in a study which varied combinations of (a) TV instruction to initiate a unit versus TV instruction to terminate the unit, (b) teacher use of a study guide versus no use of a study guide, (c) presentation of common assignments to all class members versus encouragement of pupils to work on individual projects, (d) teachers with workshop training (30 hours) in science versus teachers with workshop training in the utilization of TV versus teachers with no special training in conjunction with the study. Control classes received the TV instruction (a series of 30 half-hour natural science programs) with no additional related instruction. Results of tests of science information, science vocabulary, science reasoning and standardized science achievement revealed substantial and statistically

significant differences in favor of the experimental classes over the control (TV only) classes in science information and vocabulary, but not in science reasoning. Furthermore, where TV was used to terminate the unit, greater learning occurred where common class assignments were given to students; but where TV was used to initiate the unit, greater learning occurred where students were assigned individual projects. Teacher training provided in the workshops did not produce significant differences in student achievement. Finally, teachers who used a brief outline and suggestions for pupil projects achieved as much with their classes as teachers with the comprehensive study guide.

Schramm and Oberholtzer (1964), using over 12,000 fifth and sixth graders in a three-year experiment, found that the most effective combination of learning activities to integrate with a televised course in elementary school Spanish varied with grade level. For fifth graders, a combination of TV plus teacher-directed practice, electronic aids with feedback, and parent participation at home was most effective. For sixth graders, a combination of TV plus teacher-directed practice, programmed instruction, a "Spanish corner," and parent participation was best. Finally, in using the televised Spanish instruction, programmed instruction combined with teacher-directed practice was found to be better

than either alone. Using a large sample (13,000) of fifth and sixth graders for televised Spanish instruction, Hayman (1964) found that a second viewing of the televised lesson was more valuable when the students had no additional instruction as compared to its value when other instruction was provided.

Basic Studies

Turning to considerations of learner characteristics and learning conditions which are media-related, a University of Alabama study (1961) of the effectiveness of instruction by TV in teaching high school chemistry in Alabama schools found that results depended in part on the learner's race: Negro students using TV achieved significantly higher scores than Negro students not using TV, while significant differences in the achievement of white students showed exactly the opposite result. In the same study, availability of good versus poor laboratory facilities were related to the relative effectiveness of TV and face-to-face methods for teaching chemistry. With good laboratory facilities, non-TV groups surpassed TV groups. For Negro learners having poor laboratory facilities, just the opposite result was obtained.

In their extensive work on the use of student responses to

increase learning efficiency in televised instruction, Gropper and Lumsdaine (1960) compared the achievement of sixth and seventh graders when the televised instruction required either written or mental responding and when no such responding was required by TV. The active-response group performed significantly better than the no-response group, and this result was obtained again on a delayed retention test administered one and one-half weeks after the posttest. These results were supported by a second study (Gropper and Lumsdaine, 1961a) using seventh and eighth graders, which again demonstrated the superiority of student response over no response for televised instruction on nuclear reactions and on the effects of heat. In this instance, the televised lessons requiring student response were modified to provide opportunities for students to respond either in writing or mentally (thinking). In a later experiment, the same authors (1961b) demonstrated that a programed TV lesson (specially sequenced in small steps, with mastery of each step enabling students to proceed to the next step) requiring active responding by students yielded significantly higher achievement than the identical lesson not requiring active responding. When a lesson was not programed or specially sequenced, no significant differences were obtained between the response and no-response groups,

leading the authors to conclude that there is "little basis for believing that merely requiring or encouraging students to make active responses, without employing methods to insure that they will be capable of making correct responses, will add to the effectiveness of instruction."

Data from high- and low-ability students in the Gropper and Lumsdaine study (1961a) point up the fact that learner characteristics as well as conditions of instruction must be considered when deciding how to maximize achievement for each student. For high-IQ students, the specially programed TV lesson requiring students to respond produced significantly more learning than the conventional (no response) version, both on a test of immediate retention and one of delayed retention. On the other hand, low-IQ students retained significantly more, as measured by the delayed test, if they learned by the conventional TV lesson as compared to the programed (active response) TV lesson. Other instances of ability-media interactions were noted previously.

Exploring the effects of yet another learning condition on achievement from televised instruction, Johnson (1960) compared televised instruction in listening skills where the TV teacher had an in-studio audience to provide feedback with televised instruction where the TV teacher was alone in the studio and found no

significant difference between methods. In his review of television research, Kumata (1960a) indicates that evidence from other studies supports this finding. He points out, however, that talk-back facilities which permit an audience to interrupt the TV teacher are seldom used and may not be a satisfactory substitute for student-teacher interaction in the classroom.

Finally, in considering particular characteristics of televised presentation which enhance learning, Schwarzwald (1960) found that visuals reinforced with superimposed (reinforcing) materials and visual continuity provided by camera shots in a planned (as opposed to random) order contributed materially to high achievement in teaching fifth-grade science by TV.

Motion Pictures

Comparative Effectiveness Studies

In their chapter on mass communication and educational media prepared for the Annual Review of Psychology, Lumsdaine and May (1965) concluded that, from the standpoint of stimulus properties, "film and TV can be considered substantially identical media for many purposes." The reader will notice that the studies comparing the instructional effectiveness of films with the effectiveness of

face-to-face (conventional) classroom instruction cited below evidence a pattern of findings very similar to the television research cited in the preceding section. That is, most studies do not reveal reliable differences between instruction by films as compared to conventional methods, over a wide range of subject matter, age ranges, abilities, and conditions of use. A few studies have shown learning by motion pictures to be significantly superior to learning by face-to-face methods; other studies show opposite results favoring face-to-face over film methods.

In studies conducted at the university, senior high school, junior high school, and elementary school levels, no significant differences in achievement were found when students were taught by either motion pictures or conventional instruction in public speaking (McElroy, 1958), ninth-grade science (Champa, 1958; VanderMeer, 1950b), eighth-grade exploratory science (Huffman, 1958), high school chemistry (Popham and Sadnavitch, 1960; Sadnavitch and Popham, 1961), high school physics (Sadnavitch and Popham, 1961), college-level American government and comparative foreign governments (Stuit, et al., 1956), and college physics demonstrations (Tendam, 1961). Similarly, in a review of film research by Allen (1960), several studies were cited to indicate that motion pictures are at least as effective as

conventional instruction in teaching factual information and perceptual motor skills. Finally, Greenhill (1964), in his introduction to a volume of abstracts of research on instructional TV and films by MacLennan and Reid (1964), comments that in general, no significant differences were found in the bulk of recent studies comparing filmed courses with direct instruction in such subject-matter areas as college-level psychology and communication skills, high school chemistry, physics, history, and industrial arts.

Exceptions to these inconclusive findings are results from studies in which elementary school natural science (Cobbs, 1941), a seventh-grade lesson on light (Murphy, 1961), and a lesson on sulphur in high school chemistry (Nelson, 1952) were learned significantly better by motion-picture presentation as compared to face-to-face methods. On the other hand, conventional instruction was significantly better than filmed instruction for high school physics (Popham and Sadnavitch, 1960).

As for long-term retention of material learned by films as compared to conventional methods, Allen (1959) concluded in his review of research that retention of factual information learned by film is as good as when learned by conventional methods. The study by Cobbs (1941) supports this generalization. Occasionally,

a study has shown films to be significantly superior to conventional instruction in promoting retention of learned material (Nelson, 1952).

Comparative studies which pit films against a medium other than face-to-face instruction are very scarce. Inconclusive results were reported by Champa (1958) for comparisons between film and TV for teaching ninth-grade science. Similarly, when McGrane and Baron (1959) compared motion pictures to TV in teaching electricity, no significant differences were noted except when the noise level of the film projector was very high -- and then TV instruction was significantly favored. Harris et al. (1962) found that in teaching a unit in strength of materials, students in the combined film-and-laboratory group scored significantly higher on a test of problem-solving ability than students in the films-only and laboratory-only groups; there was no significant difference between the films-only and laboratory-only groups. Ortiegsen (1954) found a significant difference in favor of films over printed material in a ninth-grade soil conservation unit. On the contrary, Rosselot (1961), using college students, found significant differences which favored text over film-and-text for improving reading in French; however, students in the film group scored significantly higher than the text group

on the oral (taped) test. During the second year of the same study, high school students usually achieved significantly higher scores on both types of tests if they were in the film-and-text group as compared to the text-alone group. In two exploratory studies of the use of still pictures, motion pictures, and sound in teaching Russian vocabulary, Kale, Grosslight, and McIntyre (1955) found that the motion picture-plus-titles group achieved significantly higher scores than the words-alone group on a test of vocabulary recognition (as opposed to pronunciation); similarly, in one of the studies, still pictures-plus-titles produced significantly higher achievement than the words-only treatment. Comparisons between motion- and still-picture presentations revealed no significant differences in vocabulary recognition, leading the investigators to conclude that "having a picture associated with a word aids in the learning of that word." Finally, LeAnderson (1953) compared the use of a manual, a filmstrip, a motion picture, a combination of these media, and face-to-face instruction in teaching fifth graders how to use the telephone directory and the telephone. He found significant differences favoring any of the single media over face-to-face instruction. Furthermore, the group using combined media achieved at a significantly higher level than any other group.

Utilization Studies

Ketcham and Heath (1963) found that three showings of a film on the life and work of Wadsworth produced significantly more learning than a single showing of the film. McTavish (1954) compared learning from multiple showings of films on electrochemistry, colloids, food and nutrition, and atomic energy to university and high school students. He found that for all levels of students, two showings of the films produced significantly more learning than a single showing of the films. Although three showings of a film also produced significantly more learning than two showings, the learning gain attributed to three over two showings was only one-fourth that of the gain resulting from two showings over one showing. Kendler, Cook, and Kendler (1953) found that a single review showing of a film was significantly better than no review showing; also, as was found in the McTavish study cited above, increasing the number of reviews produced higher scores, but increments decreased with increase in review showings. In considering these findings, it seems appropriate to say that time spent in review (via repeated showings) is probably the most significant factor consistently shown to be important regardless of the media employed.

Teacher introductions to films have been demonstrated to

increase learning, whether the teacher asks students anticipatory questions, previews difficult vocabulary, or uses study guides to anticipate the film (Allen, 1952). Wittich and Fowlkes (1946) noted a significant difference in favor of class preparation over no preparation for films on social studies and science viewed by fourth, fifth, and sixth graders. Indirectly related to considerations of class preparation is the study by Rulon (1933), where all groups received equivalent learning materials, including filmed presentations. However, in the experimental group, the films were accompanied by related assignments (a form of class preparation). The learning gain of the experimental group was about twenty per cent greater than that of the control group. VanderMeer (1950b) used study guides before and after film viewings in one group and compared the performance of this group to a films-only group and a conventional-methods group. No significant differences among methods were noted on tests of immediate recall, but the films-plus-study guides group was consistently superior to the other groups on the General Science Achievement retest (a retention test administered about three months after original learning). For boys, this difference was statistically significant.

Investigating the effects on learning of spaced review

versus massed review in a film on elementary electricity shown to high school students, Miller, Levine, and Kanner (1952) found a significant difference in favor of massed review at the end of the film over spaced (interspersed) or no review. Anderson et al. (1956) compared (a) achievement when the teacher pointed out and stressed principles covered or emphasized in the film as well as stressing other special parts of the film with (b) achievement when the teacher made no effort to stress such points made by the film. There were significant differences in favor of teacher stress to supplement points made in the film, but only for students at the two extremes in ability.

Basic Studies

A few studies have sought to identify characteristics of learners and of the motion-picture medium which have a pronounced effect on learning. Moldstad (1955) used the Dale-Chall readability formula to vary the difficulty level of a film narration on plant life (fifth-, seventh-, and eleventh-grade levels) and showed the resulting film versions to groups of seventh graders. Tests of scientific facts and vocabulary indicated no significant differences in learning among the three groups as a result of the difficulty level of the narration. On the other hand,

Gladstone (1958) compared factual learning from two versions of a film on China's geography, economy, and culture. One version used a "difficult" commentary and the other version used an "easy" commentary containing the same factual information -- i.e., ninth- to tenth-grade level versus fourth-grade level or below -- as measured by readability formulas. Students in seventh- and eighth-grade classes were assigned to one of the two film versions. Gains from the pretest to the posttest over film content significantly favored the easy version, from which students learned thirty-three per cent more factual information than those who saw the difficult version of the film. Lumsdaine (1963) cites other research also using readability formulas in which more information was learned from the easier commentary, as compared to the more difficult versions of a film. Still other studies have investigated the relationships among the difficulty level of the film, the method of student participation used in conjunction with the film, and the learner's ability and motivation levels. Such studies have been reviewed by Allen (1957) who noted that although active participation has been found to be most effective for difficult material -- and this usually for the less intelligent, non-motivated learner -- these findings probably vary as a function of the type of learning involved (Lumsdaine and May, 1965).

Commenting on the powerfulness of the participation variable in general in his review of film research, Allen (1957) notes that out of 26 studies assessing the effects of participation on learning from films, 13 favored participation and only two favored non-participation (the remainder having inconclusive results). Travers (1964)* concluded from his review of film research on audience participation and practice that "verbalization of response" was a particularly effective participation technique. In line with this general conclusion, Kendler, Cook, and Kendler (1953) found that requiring students to make oral responses during a map-reading film produced significant learning gains over non-participating groups. A relevant study reported by Lumsdaine, May and Hadsell (1958) provided for participation by systematically evoking responses from students with printed questions

*The purpose of the review by Travers was to gather together knowledge which would contribute to the design of effective audio-visual materials, and it "represents a search for psychological principles which might be used as a basis for planning such materials." Travers therefore has included in his review many studies which are excluded from the present review, mainly those in the "production" category (see opening section of this chapter). Our purpose, in contrast, is to focus on research which might contribute knowledge about the appropriate selection and use of media for accomplishing given educational objectives.

spliced between sections of the film. The participation version of the film produced significantly greater learning than the non-participation (no inserted questions) version, and was as effective as a double showing of the film which required more time. An item analysis of test items indicated, however, that this superiority could be attributed to the items which were directly covered by participation questions. Such participation questions, it was found, were more effective than were questions designed to increase motivation.

Michael and Maccoby (1953) also found that audience participation produced significantly greater learning than non-participation for those test items which were practiced during participation. In addition, these investigators manipulated another variable -- knowledge of correct response (KCR). Comparisons between groups receiving KCR and not receiving KCR yielded a significant difference in performance in favor of KCR students over and above the effects of the participation variable, and the authors therefore concluded that providing learners with information as to the correctness of their responses during participation was the major contributor to the learning gains demonstrated in their study. Allen (1957) and Travers (1964) also concluded from their reviews of film research that knowledge of results is an extremely effective component of

the participation technique.

Ketcham and Heath (1963) attempted to assess the specific contributions of sound and visual elements of motion pictures to learning. Both their initial pilot study and subsequent main experiment indicated that for a film on the life and works of Wadsworth, a visual which did not directly portray the sound track (but which was shown with the sound track) produced significantly greater learning than the sound track alone. In a relevant study by Nelson (1949), it was found that students learned significantly more from a sound film than from the sound track alone. Lumsdaine (1963), noting inconsistent results from various comparisons of audio and visual elements of different films, remarked upon the improbability that "a consistent advantage of one or the other modality would be found to have much generality beyond the specific films (and tests) used." To establish any stable advantage of one modality over the other, it was felt that studies would have to measure comparative superiority as a function of other instructional variables (related both to the task and to the learning situation).

As for the specific kinds of material which are best presented by films, an article by VanderMeer (1941) on the specific contributions of films to teaching science reviewed a study by

Wood and Freeman in which the film group did best in recalling concrete objects and processes. In the same article, VanderMeer also noted a follow-up study by Dairs, who concluded that the film is superior in imparting information dealing with action or activity, but inferior in imparting knowledge dealing with objects. In their review of research on audiovisual materials, Dale, Finn, and Hoban (1949) indicate that studies on the value of films with respect to perception of relationships are meager and mixed. Historical photoplays, they note, have been found to interfere with development of a sense of time relationships, but on the other hand have been very effective in teaching knowledge of interrelationships involving interactions of events and forces. Other film research studies have categorized content of the experimental task as conceptual, factual, or perceptual-motor; these studies provide evidence that films can teach these types of content at least as effectively as conventional methods of instruction (Allen, 1960). While these reports tend to specify in more detail than do many other reports the nature of the particular kind of content investigated, they still suffer for failure to identify the kind of learning and the nature of the criterion performance in conjunction with the content, in a manner like that recommended in Chapter II of this report.

Programed Instruction*

Comparative Effectiveness Studies

Schramm (1964) found that out of 36 studies comparing programs with conventional instruction, half (18) showed no significant difference, but 17 showed a significant difference in performance favoring program groups. Only one study showed a significant superiority for conventionally taught groups. Briggs and Angell (1964) cited 19 studies -- five in the area of science and 14 in mathematics -- in which the effectiveness of programed instruction was compared with conventional teaching methods and noted that non-significant differences were reported more often than were significant differences. Strong (1964) cites studies comparing programed instruction with conventional instruction in a college statistics course (Smith, 1962) and a unit on use of the library (Wendt and Rust, 1962); no significant differences were found in these two studies. Porter (1959) used a teaching machine to present programed spelling to second-grade and sixth-grade children. Control groups were taught by standard lessons in textbooks which paralleled the programs closely. Significant differences in achievement on standardized tests favored the program

*Unless otherwise indicated, all programs used in the studies cited in this section required written responses by students and were linear in format.

groups at both grade levels. Evans, Glaser, and Homme (1960) used programed materials to teach part of a course on music fundamentals. The control group was taught by conventional methods. On a test of music notation, the program group surpassed the control group by a significant difference.

Roe (1962) compared the performance of groups who learned elementary probability either from programed textbooks, teaching machines, programed lectures, or conventional lectures-and-text-books. Students who used the programed material in any form did significantly better on the final exam than those who were taught by the conventional method. Furthermore, there were no significant differences in learning achievement among the program groups. Ripple (1963) taught university students principles of programing by one of four instructional methods: (a) programed instruction which supplied students with feedback as to the correctness of their written responses, (b) textbook (this was the program reproduced in textbook format -- no blanks to be filled in), (c) conventional lecture (based on reading the programed material to students), or (d) programed instruction which did not supply feedback. The two program groups learned significantly more than the text and lecture groups, with no significant difference between the program treatments (feedback versus no feedback). Finally, Moldstad (1964)

cites a study by Stewart in which college students from two universities were taught factual information by one of three methods: programed instruction, a motion picture, or a combination of the two media. (The program covered the same factual material as the first 40 frames of the film.) On a test given immediately after learning, and on the retention tests given at one-day and six-day intervals after learning, the program-only and program-plus-film groups did significantly better than the film-only group.

Utilization Studies

Klaus and Lumsdaine (1960, 1961) evaluated the effectiveness of supplementing instruction in high school physics with programed textbooks. Students in both control and experimental classes read their standard textbook, viewed televised physics films, watched and performed laboratory demonstrations, and heard classroom lectures. In addition, some of the experimental groups received programed materials which provided additional coverage of topics already covered by other methods. As a means of measuring possible effects of additional study time spent on the programs, other experimental groups were given individual workbooks paralleling the coverage of the programed text. (Under these conditions, the

performance of the students using the workbooks could be compared with that of students whose additional time was spent working on the programs.) Results of this study indicated that the programmed material made a significant contribution to the level of achievement of the students. (The workbook classes were superior only to classes which did not receive the programs and were inferior to program classes.) This study was described in some detail to make it clear that even when students were already being taught physics by several integrated methods, coverage by programmed instruction still was able to produce significant achievement gain.

A second study by the same investigators indicated that the teacher did not add to the level of achievement produced by use of a program alone; i.e., groups who learned exclusively from a physics program learned as well as groups taught by a teacher plus the program. On the other hand, Goldbeck et al., (1962) integrated the use of homework assignments in a continuous-discourse program with introductory or follow-up lectures by the teacher in a high school course in American government. Introductory lectures previewed important points in programs to be assigned for homework; follow-up lectures reviewed program topics which students found troublesome or which had not been covered in sufficient detail in the program. An item analysis of test responses indicated that students performed

significantly better on test items covered directly by both the program and the teacher than on items covered by either the program or the teacher alone. These results are especially interesting because they provide statistically reliable evidence that programmed instruction and conventional instruction can be mutually facilitating, where careful planning and preparation have been directed toward this end. In the same study, no teacher differences were found regarding the instructor's ability to use the integrated programmed instruction. In harmony with findings from the Goldbeck study, Hatch, and Flint (1962) found a significant difference favoring the overall effectiveness of programmed-plus-conventional instruction in basic electronics (junior college) as compared to using either instructional method alone. (When results from the use of the single methods were evaluated, program groups and conventional classroom groups achieved equally well.)

In a series of studies with elementary school children conducted by Campbell (1964), achievement of students who were allowed to direct their own learning activities was compared with that of students who completed linear programs. For several subject-matter areas, no significant differences were noted between linear program groups and self-directed groups. However, in one study with mathematics material, a significant difference was found favoring

"coached" self-directed students, indicating that the effectiveness of self-direction may depend on teaching students how to direct their own learning activities. Also, a significant difference was obtained favoring self-directed students in a history experiment, where achievement was measured by a transfer test in which students had to apply knowledge of history to hypothetical historical situations. In these experiments, materials for self-directed students were not conventional texts; they consisted of packets of statements of objectives, self-test items, reading materials, maps, etc., from among which each student chose what to use and when to use it.

Basic Studies

A great deal of research has been devoted to determining specific characteristics of programmed instruction which will increase its effectiveness. Additional effort has focused on determining learner characteristics which may interact with program characteristics in affecting achievement. In order to lend some structure to the several studies which will be reported here as examples of basic research, citations will be discussed under two sub-headings: program variables, and learner variables.

Program variables. Studies of program variables have raised questions such as these:

1. Knowledge of correct response. Does providing the student with answers with which he can check his responses increase learning? And if so, what form should this feedback take and how frequently should it be provided?

2. Prompting versus confirmation. Will prompting the student before he responds, or will confirming the correctness of his response, result in highest achievement?

3. Response mode. How should students respond to program items: write out answers, answer mentally, or simply read through a program in which no blanks need to be filled in?

4. Hardware versus software. Will students learn best if programed material is presented by a machine, by a projection device (e.g., TV or filmstrip), or by a printed textbook?

5. Pacing. Will a student learn best at his own pace (as when he works through a programed text or operates his own teaching machine) or at some fixed pace (as when programed material is presented by a device which controls the rate at which material is viewed, e.g., by TV or film projection)?

6. Step size. Will students learn best if presented with smaller or larger bits of information before being asked to

respond?

Other topics considered by basic studies on programmed instruction will not be dealt with here due to space limitations. These include studies of branching and bypassing programs, logical versus random sequencing of items, optimum review schedules, cueing and vanishing techniques, programing strategies (RULEG, guided discovery, etc.) and optimum error rate.

The six types of studies on program variables which were enumerated above will now be considered.

1. Knowledge of correct response. Most studies have found that providing students with immediate knowledge of results at frequent intervals enhances learning (Schramm, 1964). Three studies which have not supported this generally accepted finding have been reported by Glaser and Taber (1961) and Moore and Smith (1962a, 1962b). In the study by Glaser and Taber no significant difference was found between learning when feedback was provided after one-quarter to one-half of the responses as compared to feedback after all responses. They suggested that knowledge of results is more important in a program in which the probability of making wrong responses is high; their program was evidently easy enough that receiving feedback consistently throughout was relatively unimportant. Moore and Smith found no difference

between feedback and no-feedback groups using spelling and psychology programs. In their studies, the spelling material was evaluated as quite easy by the authors; also, there was a high degree of frame-to-frame redundancy which reduced the need for formal feedback. In the psychology program, no precautions were taken to prevent students in the no-feedback group from flipping back to previous frames for help. Another author, Ripple (1963), also attributed his failure to find a reliable difference between feedback and no-feedback groups to the use of a program with a low error rate. These studies emphasize the fact that there may be more sources of feedback in a program than the formal feedback term supplied by the programmer. Only in programs where other sources of feedback are minimized can the effects of formal feedback on learning be effectively manipulated.

Other studies have been concerned with the form feedback should take. Measuring achievement with a test of ability to apply principles learned in the program, Krumboltz and Bonawitz (1962) found that providing feedback in the context of a complete sentence was significantly superior to presenting the feedback term alone.

A study frequently cited as evidence that accompanying feedback with an explanation enhances learning is the study by Bryan and Rigney (1956). College students in the group receiving

feedback plus an explanation scored higher than both a group receiving no feedback and a group receiving feedback without an explanation. A follow-up study was conducted to determine the relative effectiveness of three different types of feedback (Bryan, Rigney, and VanHorne, 1957): (a) feedback which gave the correct definition or description of the chosen alternative; (b) feedback which indicated the reason why an alternative was correct, and (c) feedback which pointed out probable "operational consequences" of the course of action represented by the alternative. No one type of explanatory feedback was found to be superior. Unfortunately, no provision was made in the second study for groups receiving no feedback, or feedback without any explanation.

The only research discussed here on delay of feedback will be the quite comprehensive and analytic series of studies by Brackbill et al. (1964) which have been reviewed by Briggs and Hamilton (1964). Brackbill found that delaying feedback (by a specified number of seconds) during learning improved retention over a wide range of tasks which varied in meaningfulness and difficulty. While the relative amounts of increments in retention resulting from delayed feedback varied as a function of subject-matter variables, the superiority of delayed feedback was consistent across tasks.

2. Prompting versus confirmation. Under the classical prompting condition, the stimulus material and the correct response are presented to the student simultaneously (after which the student may be required to repeat the response). Under a confirmation condition, however, the student responds after the stimulus material is presented, and then he is told or shown the correct response (confirmation). (Programed instruction typically employs a procedure, called cueing, which falls somewhere in between prompting and confirmation. A cue is less direct than a prompt in amount of guidance given to the learner, and is followed by confirmation.) Briggs and Hamilton (1964), reviewing studies of prompting and confirmation techniques, conclude that there is general agreement on the superiority of prompting over confirmation for paired-associate material, whether meaningful or meaningless, for meaningful serial learning, and for simple problem-solving tasks requiring a recognition rather than a recall response. Studies by Angell and Lumsdaine (1960, 1961), using paired-associate tasks, have qualified the findings in favor of a mixture of prompting and confirmation by a study in which prompting on three-fourths of the trials (and confirmation on the other fourth) was more effective than either prompting or confirmation on all trials. Briggs and Hamilton (1964) note there is other

evidence suggesting that techniques combining prompting and confirmation are even more appropriate for both meaningful materials such as presented by programmed instruction. Prompting and confirmation studies they cite include those by Cook (1958), Cook and Kendler (1956), Cook and Spitzer (1960), Angell and Lumsdaine (1961), Briggs (1961a), Sidowski, Kopstein, and Shillestad (1961), and Goldbeck and Campbell (1962).

The studies cited above have to do with variables which, in the language of teachers, are known as "didactic" teaching (prompting) and "guided discovery" (less prompting, as in the cueing in programmed instruction). The findings quoted above (mostly from laboratory studies) appear to lend general support to the notion that didactic methods may be best for memorizing, and a greater degree of discovery best for learning to solve problems. However, many teaching procedures are really mixtures of these techniques, and the advantages of either method are not very clear, except when analyzed as "instructional events" (see Chapters II and III).

3. Response mode. Briggs and Angell (1964) concluded in their review of programmed instruction research in science and mathematics that "overt responding has not been shown to be a requirement for learning from autoinstructional programs." For

example, Evans, Glaser, and Homme (1962) reported no significant differences in achievement as a result of learning under overt (written), covert (mental), and reading response modes, using a program on symbolic logic. In a study by Alter and Silverman (1962), no significant differences were found among groups who studied a program on basic electricity requiring overt-written, covert, reading, overt-spoken, or written-plus-spoken responses. Two additional studies failed to find differences in learning attributable to either overt or covert response modes; one study used a program in descriptive statistics (Stolurrow and Walker, 1962) and the other used a program on sets, relations and functions (Lambert, Miller, and Wiley, 1962). Schramm (1964) cited 16 studies to support his conclusion that the majority of studies on overt-versus-covert responding find no significant differences between response modes. On the other hand, Deterline (1962) cites a study by Holland (1960) who found a significant difference in achievement favoring students who wrote down their responses (overt mode) over students who merely "thought" their responses (covert mode) and over students who read program frames in which no words were left blank (reading mode).

Some studies suggest that advantages of any given response mode may be confounded by differences in the complexity or

difficulty of the subject matter. In a study by Goldbeck and Campbell (1962), discrete factual information was programed using three difficulty levels and three response modes -- overt (written) responses, covert (mental) responses, and reading only. At the lowest difficulty level, the overt response group was definitely inferior to the covert and reading response groups, with differences being significant for each comparison. However, for material of a medium difficulty level, overt responding was significantly superior to covert responding; its superiority over the reading-only mode was not significant. At the high difficulty level, no significant differences were found among the three response modes. On the other hand, in a second study the same authors used continuous-discourse materials estimated to be of intermediate difficulty level, and they found that the reading-only group was superior to overt and covert response groups on a retention test given 10 weeks after learning. Stolurow (in press) cites a study by Eigen and Margulies (1963) in which overt response students performed better than thinking response groups only for learning material of intermediate and high difficulty levels. For low-difficulty material, no significant differences were found between overt and covert response modes. A study by Krumboltz (1963) suggested that any advantage for constructed response over simply

reading material may depend on the criticalness (as opposed to trivialness) of the required response. The combined results from the Goldbeck and Campbell, Eigen and Margulies, and Krumboltz studies suggest that students should be required to make overt responses only where responses are difficult or novel for the student to make, requiring him to assimilate necessary information which is critical to the response. Lumsdaine and May (1965) predict that overt responding will be more effective when: (a) the task is to learn responses, as opposed to learning the association between a new stimulus and an already learned response; (b) the task involves rote memorization, as opposed to meaningful context learning; (c) the task is difficult, learners are very young, and conditions are distracting; (d) the learner makes appropriate implicit responses which he would not make unless required to give overt responses; (e) the learner responds more adequately to other portions of the instructional sequence as a function of the expectation that he may be called upon to respond overtly at unpredictable checkpoints. These expectations appear generally to be consistent with research findings cited above. It should be noted, however, that this research calls attention to the response-making aspect of total learning situations -- an aspect

relevant for only some instructional events. It remains for research on special topics, like promptingconfirmation and response modes, to be sufficiently related to other variables in the total instructional procedure to result in detailed guidance for practice. Stated differently, research in response modes and prompting has been conducted for those types of tasks, those instructional events, and those media (programed instruction) which emphasize the importance of responding and the importance of ways to elicit and reinforce responses. For instructional events like goal setting, and recall and selection of relevant rather than irrelevant concepts, other factors appear to be important in the design of instruction.

Mixed results have been obtained in studies comparing achievement between groups who wrote out their answers during learning and groups who selected their answers from multiple-choice alternatives. Schramm (1964) cites four studies finding no significant differences between constructed and multiple-choice response modes and one study finding an advantage for constructed response. Lumsdaine (1963) cites a study by Coulson and Silberman (1960) which measured the effects on learning of constructed versus multiple-choice responding in a programed lesson on behavior. No overall significant difference

in achievement was noted, but the multiple-choice group took much less time than the constructed-response group (a typical finding). Fry (1960) used Spanish-English vocabulary rather than continuous-discourse materials to compare the effectiveness of constructed versus multiple-choice responses. No significant difference was noted on the multiple-choice test; but on the constructed-response test, students who had been required to provide constructed responses during learning performed significantly better than students in the multiple-choice group. (The same superiority was noted on a constructed-response test in the Coulson and Silberman study, even though no significant overall effects were obtained. In neither study, however, was an analysis reported of any attempt to assess the superiority of the constructed-response mode in terms of the increased time required for responding in this manner.) In a study reported by Briggs et al. (1962), students who responded to multiple-choice questions over large segments of reading material scored higher on tests phrased unlike the way study questions were phrased than did students who wrote in responses to a small-step linear program.

4. Hardware versus software. Comparisons between text and machine presentations of programmed material are typically inconclusive (Stolurow, in press; Goldstein and Gotkin, 1962).

The point is made that these studies compare relatively simple teaching-machine presentation devices with current programmed texts and are not relevant to future experiments utilizing highly sophisticated, complex equipments which may have unique advantages over programmed-textbook presentation. Carpenter and Greenhill (1963) used students in a contemporary (college) algebra course to make comparisons between presenting a programmed course by teaching machines, programmed textbooks, and filmstrips. No significant differences in performance among the three programmed treatments were shown. As part of the same series of experiments, the same investigators conducted two more experiments with English grammar classes. One study found no differences in achievement among students taught by TV presentation of the programmed material and students taught by teaching-machine presentation. The second of these two studies again failed to find any significant difference in performance for students taught by lecture-discussion methods and students taught by a programmed course presented over TV.

5. Pacing. Pacing studies seem to have been a logical next step from gross comparisons of hardware and software presentation devices. Three studies in a series of experiments by Carpenter and Greenhill (1963) compared effects of self-pacing

(students used programed texts or teaching machines) with externally controlled pacing (students viewed programed material on TV or films). Subject matter was either college mathematics or English. They found no significant difference due to the pacing. Frye (1963) was able to demonstrate that external pacing of a program was less satisfactory (took longer to master) if students were grouped heterogeneously; for the homogeneous ability groups, external pacing took no longer than self-pacing. In summary, Schramm (1964) notes that, although it seems learning should be enhanced by allowing students to proceed at their own pace, "the experimental literature has not been able to demonstrate as much advantage for individual pacing as might be expected."

Additional light was shed on the pacing variable by Kress and Gropper (1964). They projected programed instruction on a TV screen at various presentation rates. It was demonstrated that student performance under a given fixed-rate presentation was a function of the individual's own pace, as determined under self-paced conditions. That is, under fast, fixed-pace presentation of the programed material, students who under self-paced conditions consistently and successfully (as measured by achievement tests) worked at a fast pace could readily adapt to the

externally set fast presentation rate. On the contrary, under slow, fixed-pace presentation, the performance of characteristically fast students was actually inferior to that of slow students in the slow-pace group and to that of fast students in the fast-pace group! (Since IQ was controlled for, these results cannot be attributed to the influence of ability on achievement.) Comparisons between characteristically slow students were as expected: performance was much better under the slow fixed-pace than under the fast fixed-pace presentation of the programed material. These recent detailed studies are in agreement with an earlier study by Briggs, first reported in 1951 and reprinted later (Briggs, 1961b), in which there was no significant difference between self-pacing and group-pacing at the average rate best for all students.

6. Step size. Many reviewers have noted that this topic is difficult to review because "step size" has a number of different meanings and connotations, ranging from "difficulty of responding" to "amount of reading material per response requested" (Schramm, 1964; Lumsdaine, 1963; Stolurow, in press; Briggs and Hamilton, 1964). In general, however, when significant differences have been found, they usually have been in favor of programs with relatively small step size, regardless of differences in

procedures for measuring step size (Evans, Glaser, and Homme, 1960, 1962; Coulson and Silberman, 1960). On the other hand, Smith and Moore (1961) found no significant differences in rates of learning to spell with variations in step size. Moldstad (1964) cites a study by Keith Hall at Pennsylvania State University in which a commercial spelling program was rewritten in three versions varying in three sizes of step and three types of cue. He found that effects of these two variables varied with ability level, such that high-IQ students did best if presented with large steps; low-IQ students did best with small steps.

It would probably be unwise to rely on findings from step-size studies until a satisfactory definition of the terminology makes the results interpretable.

Learner variables. Several investigators have found that individual differences among learners may be related to the effectiveness of sundry program variables. These learner differences may pertain to intellectual or personality characteristics, or they may be differences in sex, age, grade, socioeconomic background, interests, motivation, and so on.

Campeau (1965) found a significant interaction between anxiety level and the presence or absence of feedback in programmed instruction. In her study, high-anxious girls scored

significantly higher on a test over a program on earth-sun relationships, if the program they learned from provided feedback (answers to program items) as compared to no feedback. The results were reversed for low-anxious girls. That is, low-anxious girls scored significantly higher on the test if the program they learned from withheld feedback as compared to providing feedback. No significant differences were noted for boys.

Porter (1961), cited earlier, studying IQ differences in relation to effective method of instruction in spelling, found that in the second and sixth grades especially, the greatest gains for all IQ-method combinations were made by low-IQ students who were taught by programmed instruction; the least gains of all were made by low-IQ students receiving conventional instruction. McNeil (1962) found that in teaching elementary reading skills to kindergarten children by programmed instruction, the requirement for oral responding was particularly effective for low-IQ children. Also, boys learned significantly more than girls from the programmed instruction. In one out of five studies of bypassing programs, Campbell (1962) found that, for students who ranked above the 50th percentile on the numerical scale of the Differential Aptitude Test, a bypass program on set theory which enabled students to skip ahead based on correct responses to

program items resulted in significantly better performance than the linear format of the program. On the other hand, both versions of the program (bypass and linear) worked equally well for low-ability students. Campbell also noted that bypassing was most useful when the topic had a hierarchical structure. Stolurow (in press) summarizes Campbell's study and suggests that grade level will be related to hierarchical structure, since the older the child, the more pre-requisite information and knowledge may already be in his repertoire, and the easier it will be to learn subsequent material.

NOTE to the reader: Classroom studies of the media discussed in the remainder of this review are relatively scarce, and in certain areas (e.g., three-dimensional models, radio and recordings, pictorial illustration) out of date, narrow in scope, or almost completely confined to military research. For this reason, research on the remaining media will be summarized in a cursory fashion, supplemented by descriptions of a few studies where appropriate and available.

Filmstrips, Slides, Transparencies, and Other
Pictorial Presentations

Comparative Effectiveness Studies

In his 1960 review of audiovisual communication devices, Allen (1960) concluded that the research up to that time, which compared filmstrips and slides with either silent or sound motion-picture instruction, found in general that such projected still pictures were about as effective as silent or sound films in teaching factual information. Studies summarized in Allen's review include early studies by Brown (1928), James (1924), and McClusky (1924), as well as later studies by Goodman (1942), Carson (1947), P. E. Vernon (1946), Heidgerken (1948), Anderson et al. (1951), Jackson (1948), Abramson (1952), Stampolis and Sewell (1952), Slattery (1953), Lasser (1954), Zuckerman, (1954), and UNESCO (1951). These studies covered a wide range of subject-matter areas including spelling, nursing, mechanics, economics, social studies, health education, and safety education and were used with various grade levels from elementary school to the university.

Allen (1959) suggested that filmstrips and slides have been found to be at least as effective as films because of special learning conditions for which they are especially suited, e.g.,

individual pacing and student participation. Wendt and Butts (1962) remark on the preponderance of findings of no significant differences in studies comparing filmstrips, slides, and transparencies with other media (e.g., lecture, still pictures, motion pictures), and they cite studies by Dworkin and Holden (1960), Sprague (1955), and McBeath (1961). However, a study comparing the use of transparencies to the use of the chalkboard for teaching engineering drawing (Chance, 1960) did find significant differences in favor of transparencies. It seems likely that characteristics of the subject matter (engineering drawing) could have interacted with media in such a way that the clearer representation one would expect from a specially prepared transparency as compared to a chalkboard sketch would be especially crucial to instructional effectiveness. In a quite different subject-matter area, Slattery (1953) used informational and conceptual learning in fifth-grade social studies to evaluate the relative effectiveness of silent filmstrips and sound motion pictures. The filmstrips, with or without student participation, were significantly superior to the motion pictures. Again, one wonders what qualitative differences between the two media may have contributed to this finding. In an earlier review of the research on filmstrips and slides, Hoban and VanOrmer (1950)

suggested that where filmstrips have been found superior to motion pictures, this was probably due to the slower rate of instruction used in actually presenting the filmstrip to the viewers. On the other hand, they continue, the superiority of motion pictures to filmstrips in other studies could result from the greater adaptability of movies for portraying interacting events.

Wendt and Butts (1962) cited a study by Weintraub (1960) in which second graders either read stories unaccompanied by pictures, read stories which were supplemented with pictures, or saw pictures unaccompanied by the textual material. He found that reading comprehension was best when no pictures accompanied the stories. Allen (1960) concludes in his extensive review of instructional media that there is a dearth of research on the educational value of pictorial illustration, and that what little evidence has been reported amounts to a few pro- and con- findings which contradict each other. He suggests there is a need to study factors within pictorial illustration that lead to increased learning, to identify the kinds of content best communicated by still pictures, and to evaluate various techniques for implementing their use.

In a special case of pictorial presentation, Lumsdaine (1963) cited two studies by M. D. Vernon (1950, 1952) in which no reliable

differences were found in the relative effectiveness of using pictorial charts, numerical tables, graphs, and words to convey factual information. The task in the 1950 study was for British grammar school students to graph the results of comparisons in vital statistics when presented by pictorial chart, graph, or numerical table, with or without printed text material. In a summary of a series of studies and articles in England on graphic presentation, M. D. Vernon (1953) concluded that (a) special training in reading and interpreting graphs is required in order for them to be effective for instructional purposes, (b) certain types of data require certain types of diagrams, and (c) accompanying diagrams with explanatory text or comments generally enhances understanding.

Other Studies

As can be assumed from combining utilization and basic studies under this catch-all heading, the research in these categories is meager. A utilization study by M. D. Vernon (1952) failed to reveal reliable gains from using pictorial charts to accompany, precede, or follow reading of the text material.

In basic research by Lumsdaine (1958), various combinations of pictures and words were used in studies of paired-associate learning. Lumsdaine concluded from the results he obtained that

using pictures to represent the first object of a pair was significantly better than use of a printed word. On the other hand, using a printed word to represent the second (response) term of a pair was significantly better than using a picture. These results were confirmed by studies using college and grade-school learners, individual and classroom presentation, and bright and slow learners. In his chapter on instruments and media of instruction, Lumsdaine (1963) cites studies by Kopstein and Roshal (1954, 1961) with Russian-English vocabulary which lent additional support to his findings. Kale, Grosslight, and McIntyre (1955) found that for teaching Russian vocabulary, pictures contributed to learning, still pictures and motion pictures were equally effective, and regarding the use of sound, pronunciation of words by a narrator tended to interfere with learning to write words.

Related to the study of the role of visuals in instruction was research done by VanderMeer (1950a), this time using American history classes (eighth graders and eleventh graders) which were assigned to a reading treatment and a filmstrip treatment. Although there were no significant differences in performance between the two groups, an item analysis of test responses showed that while the reading group did significantly better on several

items, the filmstrip group did significantly better on an equal number of other items. VanderMeer concluded that learning may have been impaired where the picture (filmstrip) was deficient in detail, clarity, or definition. The filmstrip was also less effective for teaching factual information. Where the filmstrip group was superior to the reading group, he notes that this frequently was where the filmstrip was used to define or illustrate an important term or concept; alternatively, the reading material covering these same test items may have been relatively weak (i.e., may have buried important information in descriptive phrases and clauses, or near the end of a paragraph).

Silverman (1958) used static or animated transparencies to teach facts about firearms to college students and found a significant difference in achievement in favor of the animated group on a performance test, but not on a pencil and paper test. Allen (1960) cites two studies concerned with learning from slides (Butts, 1956; Vergis, 1954). Butts found that students who viewed slides with declarative or imperative captions performed significantly better on a test than a group viewing slides which were captioned with questions. Vergis concluded that three-dimensional slide projections of pictures are most advantageous where certain spatial concepts are being taught. The basis for his

belief was that three-dimensional projections were no more effective than regular (two-dimensional) projection of slides for teaching fifth graders factual information, and yet three-dimensional slides were greatly superior where students were to interpret size and form in space.

Radio and Recordings

Comparative Effectiveness Studies

Reviews of research on radio and tape recordings (Allen, 1960; Wendt and Butts, 1962) reveal that relatively little evidence on the instructional superiority of these media is available. This is due in part to the small number of relevant classroom studies which have been published, and in part to inconclusive findings where evidence is available. For example, Allen (1960) states that, in general, radio and recordings have been found to be at least as effective as conventional instruction. He cites two studies (Barr, et al., 1942; Cook and Nemzek, 1939) which were inconclusive regarding the effectiveness of classroom radio instruction, and two studies (Wiles, 1940; Miles, 1940) in which radio instruction produced superior learning as compared to conventional methods. Wendt and Butts (1962) cite five studies

indicating no significant differences in the instructional effectiveness of tape recordings when compared to conventional instruction, and one study with differences in favor of conventional over tape-recorded instruction. Again, the research reviewed in both cases covered a variety of subject matters and a large age range.

A recent study on the use of radio in elementary school science instruction was reported by Constantine (1964). In this study, the instructional effects of radio were measured by comparing achievement in science by conventional classes and experimental classes (the latter being exposed to a weekly educational broadcast of general relevance to science education in addition to correlated classroom instruction). Tests administered after five months of the project indicated gains by experimental students on measures of both science learning and work skills which were (for each measure) over twice the gains of the control students. Constantine attributes the dramatic gains by the integrated radio group in part to "the motivating forces of the radio." On the other hand, a study by Barrow and Westley (1959), cited earlier in this chapter, demonstrated the superiority of TV presentation over radio presentation of current events (scripts for both media having been prepared by the same script writer).

Achievement was assessed in terms of the amount of factual information learned under each method.

Popham (1961) taught a graduate-level course in educational research by a series of tape-recorded lectures combined with brief instructor-led discussions. When the experimental group was compared with a group taught by standard lecture and discussion methods, no significant differences were found. Similarly, results of a later study (1962), in which Popham used student-led discussions and tape-recorded lectures in the experimental group, again failed to show significant differences between achievement of experimental and control groups. This time the subject matter was a college course on Principles of Secondary Education.

In his discussion of research on teaching foreign languages, Carroll (1963) notes that few experimental studies have investigated questions of "how much and in what ways the tape recorder (often incorporated into the language laboratory) may contribute" and "the degree to which the tape recorder may be expected to take over some of the functions of the instructor." He criticizes the few studies available on the grounds that uncontrolled factors or other deficiencies from the standpoint of "valid research methodology" prevent any reliance on their findings. Carroll goes on

to point out a carefully controlled study by Pickrel, Neidt, and Gibson (1958) which evaluated the instructional benefits from using a tape recorder in junior high school Spanish classes taught by regular classroom teachers without prior knowledge or training in Spanish. Control students were taught by a trained Spanish teacher. A comparison of students randomly chosen from experimental and control classes indicated no significant differences between methods; however, when data from all students were used in the analysis, three of the four comparisons of control classes with experimental classes favored the controls. In another study, using university language students (Antioch College, 1960), no significant differences in achievement were noted in comparisons between experimental classes (using a combination of conventional methods and a language laboratory) and control classes (using only conventional methods of instruction). Moldstad (1964) cites a study by Lorge, who compared achievement in French under two instructional conditions: one in which students used a language laboratory and another in which no language laboratory facilities were used. For ninth graders in beginning French, the laboratory group was significantly superior to the no-laboratory group on a measure of fluency. Tenth graders in second-year French who had the laboratory experience were

superior to no-laboratory students in both fluency and intonation. Eleventh graders in the laboratory group were significantly superior to no-laboratory students in ability to understand spoken French.

Other Studies

Regarding utilization and basic studies conducted in our elementary and secondary schools or universities, no experimental analyses of specific utilization techniques of these media and no basic research reports on radio and recordings were discovered during this literature search.

Three-Dimensional Models

Comparative Effectiveness Studies

Three-dimensional models include materials such as mockups, cutaways, and actual instruments to be studied (e.g., a real micrometer for teaching use of the micrometer). As has been indicated by Allen (1960), most of the research on the instructional effectiveness of three-dimensional materials has been done by military organizations. The general indication is that the demonstrated advantages of such materials are small in relation to their high cost. There was also the suggestion that three-

dimensional materials may be most effective where the task to be learned is the actual manipulation of such objects, while other media are effective for teaching components of knowledge which support such manipulations.

Allen goes on to cite two high school classroom studies (Evans and Ray, 1954; Los Angeles City Schools, 1955) which compared instruction using three-dimensional aids with instruction which did not employ three-dimensional materials. In the study by Evans and Ray, oral instruction in one group was supplemented with micrometers (supplied to each student); in the second group, no micrometers were available and instead, oral instruction was supplemented with a large wall model of a micrometer. The second (wall model) group made fewer errors than the three-dimensional group on naming the parts of the micrometer, but no significant differences were found between groups on a test of ability to measure with the micrometer. The comparison in the Los Angeles City Schools study was between one group for which regular instruction in driver education was supplemented with the use of a mockup, specially prepared films, and some on-the-road training, and a second group which was taught as prescribed for the California driver-education course (i.e., no three-dimensional materials prescribed). Both groups performed equally

well in terms of driving skill.

Wendt and Butts (1962) reviewed educational research in the use of three-dimensional materials, noting once more the typical pattern of inconclusive results when such models are compared to conventional instruction. They were able to find only one recent study (Redell and DeVault, 1960) in which a significant difference was found as a result of using three-dimensional devices. In that study, fifth-grade mathematics classes learned significantly better when regular instruction was supplemented by use of an abacounter, calculator and other teacher-made aids.

Other Studies

No classroom studies in the utilization or basic categories could be located. On the other hand, discussions of the advantages of instructional three-dimensional models and reports of current classroom practices in their use appear frequently in various educational journals. A typical article (no author) entitled, Models: A new concept in teaching aids, appeared in the July, 1959, issue of Texas Outlook. Such articles, pointing up characteristics and capabilities of three-dimensional models which make them valuable instructional aids, cite no experimental evidence to substantiate claims made. There is thus a great need for research

designed to assess the relative effectiveness of various methods of using such devices, and for analyses of the particular characteristics of three-dimensional materials which make them more effective than other audiovisual materials for given types of learning.

Field Trips

Comparative Effectiveness Studies

There is even less experimental evidence concerning the value of field trips than concerning all other media reviewed here. In their earlier review of audiovisual materials of instruction, Dale, Finn, and Hoban (1949) concluded that the field trip was a very effective instructional technique. Subsequent reviews by Olson and Bharnuratna (1956) and by Allen (1960) indicate that very little experimental research has been conducted since that time. These two reviews each cited a study by Curtis (1944) in which field trips were superior to filmstrips in teaching factual knowledge about the dairy and about the operations of a newspaper to secondary school children, and another study by Helliwell (1953) in which it was demonstrated that the field trip was an effective summarizing device in teaching conservation to fifth graders. An early study by Clark (1943)

found significant differences in achievement in favor of field trips for sixth-grade units on printing (a trip through a newspaper plant), transportation (a train trip and bus trip), and communication (a visit to a main telephone exchange). However, he found a significant difference in favor of the control (conventional) class for an Egypt unit (the unsuccessful trip being a tour of the Egyptian room at an art institute). In the only recent experimental study which could be located (Benz, 1962), four ninth-grade general science classes were employed to measure the relative value of two instructional techniques: half the students in each class were given a field trip, and half were shown slides of the region visited by the other students. In general, no significant differences were noted between methods, the exception being that in one class the field trip group learned significantly more than the slide group. Benz aptly suggests that further research might take into account the "particular outcomes which may be due to each method." This recommendation needs to be heeded in all areas of audiovisual research, as discussed in the closing section of this chapter.

Other Studies

No experimental studies beyond the comparative effectiveness type cited above could be located.

Limitations of Current Research
and a Suggestion for Future Research on Educational Media

Limitations of Current Media Research

In an opening section of this chapter, the shortcomings of audiovisual research were reviewed in terms of methodological defects frequently encountered. In this section, other limitations of media research are identified in terms of important questions which have not yet been answered by studies here reviewed.

The media research cited in the foregoing sections sought answers to questions like these:

1. Comparative effectiveness studies: "Can TV teach better than a teacher who is unaided by televised presentation?" "Can programmed instruction teach a lesson better than the standard textbook-and-teacher presentation?"
2. Utilization studies: "Will introduction, follow-up, and review by the teacher substantially increase learning from a film?" "Will accompanying, preceding, or following text material with pictorial charts add materially to the amount learned from the text material?"
3. Basic studies: "Will students who respond in writing to programmed material of various difficulty levels learn substantially

more than students who respond mentally to the same programed material?"

These are important questions, to be sure, but to date research has not provided much generalizable information. This was brought home rather forcefully in the process of conducting the analyses reported in Chapters III and IV of this report. In those chapters, several specific learning objectives were used to illustrate the application of a procedure for selection and use of media. In those analyses, the actual choices of media could not be made on the basis of media research; the choices rested more directly upon the more analytical research conducted primarily in the laboratory environment. Even so, the choices also had to involve more decisions based on intuition than is desirable. Thus, neither laboratory nor media studies has provided complete enough information to eliminate the uncertainties involved in making such choices.

Of course, classroom teachers have been choosing and using media to teach children for years, probably basing their decisions on a mixture of past experience and intuitive judgment, rather than on any explicit, systematic process. The point is that neither the learning psychologist nor the classroom teacher can justify such decisions entirely on the basis of present research evidence.

Consider the case of the learning psychologist who has completed the first three steps of the media-selection process. That is, he has (a) specified learning objectives, (b) identified types of learning involved, and (c) determined kinds of instructional events (learning conditions) which must be provided in order to insure that the objective will be met. His next step is to select instructional media and methods which will supply these learning conditions. He turns to the media literature, and what does he find? He finds that reports of research do not specify the precise nature of learning activities for which a given medium was superior. He finds, instead, cryptic descriptions of lesson content such as, "a high school course in botany," "a ninth-grade general science lesson," or "a tenth-grade unit on plant life." Subject-matter descriptions of this sort are not very helpful because one cannot be sure what types of learning were involved. The learning psychologist must then resort to extrapolations of findings from laboratory studies to conduct the analysis of the learning conditions (step c, above).

Consider also the classroom teacher who wishes to teach his students to (a) define photosynthesis, (b) draw a flow chart depicting the process, and (c) recognize instances in plant specimens where the process of photosynthesis has been terminated.

Can the teacher determine if the results of prior media research, in which instructional objectives have been subsumed under "a high school course in botany," "a ninth-grade general science lesson," and "a tenth-grade unit on plant life," are applicable to his objectives relating to photosynthesis? No, he has no way of determining this from descriptions in the research reports, and he hasn't time to request the investigators to send him learning materials used in their studies so he can judge whether his objectives appear to be like those for the experiments reported. Furthermore, he does not have the training to attempt the kind of analysis the learning psychologist would resort to at this point in order to use findings from laboratory studies, so he is forced to rely upon his own hunches.

A Suggestion for Future Research in Educational Media

There are several views as to how the current status in media research could best be improved. In his analytical review of selected media studies sponsored by the U. S. Office of Education, Norberg (1961) observed, "The present common research practice of trying the new medium or the new practice first in one subject-matter area and then another, is justified, perhaps, on the grounds that our present theoretical base doesn't seem to provide for better alternatives." This view essentially adds up

to the conclusion that nothing can be done until theory improves. A similar view is expressed by Glaser (1962), who anticipated that "... application of current theories of learning will be less fruitful at the present time than application of current findings." The view of the present writer is that even current findings will be of very limited usefulness until media research systematically provides for the (a) explicit definition of learning tasks used, (b) careful identification of learning conditions required by these tasks, (c) judicious selection of media to be evaluated, and (d) thorough analysis of media-, learner-, and environment-related characteristics to determine the nature and extent of their influence on experimental results.

It is believed that research on educational media could be improved by adopting some of the features of laboratory research. The crux of this suggestion for improving media research involves adopting a new strategy for defining the task and for selecting which media and methods to investigate. The proposed strategy constitutes a departure from present approaches to media research, as will be indicated in the paragraphs which follow.

Current strategy. In general, it seems evident that the current approach to research on educational media is merely to select some medium or media one is interested in evaluating, and

next to select some unit or course as a vehicle for (a) comparing the relative effectiveness of various media or various utilization techniques, or (b) determining whether certain learner and media characteristics will influence learning. Which media to compare, which utilization methods to evaluate, which learner and media characteristics to examine is decided pretty much independently from any considerations of subject-matter structure and type of learning represented. The result is that an entire unit or course is programed, or produced as a series of televised lessons, or adapted to film presentation without identifying specific instructional objectives to be met, and without analyzing the types of learning involved and/or the conditions of learning or instructional events required. Given this procedure, when a single medium is used to present an entire lesson, unit, or course, and achievement resulting from this presentation is compared with achievement from essentially the same presentation by an alternative medium, it is quite feasible that each medium alternately succeeds and fails in supplying the (unspecified) array of learning events required for the various elements in the total learning task. Whether comparisons take into account effectiveness of media or methods, or identify special characteristics of learners and media which influence learning, it is furthermore quite feasible

that over the duration of a lesson, unit, or course, the net result of these alternate successes and failures, when expressed as total criterion test scores, is to conceal real differences which do exist. Hence, perhaps, the great preponderance of "no-difference" findings in media research.

The proposed strategy. According to the approach now proposed, the process outlined in Chapter II would be used to plan and design media research, as well as to prepare instructional materials during the interim period before the results of such research are available. In terms of the research operations required, the implications of the present recommendation are as follows:

1. The subject matter to be taught in the experimental task would be analyzed according to the procedure described in Chapter II, in order to determine which specific instructional events are needed for learning to occur. This represents a definite departure from current research practice, which evaluates a medium's effectiveness for presenting stimuli without first analyzing which stimuli are required by the learning task.

2. Alternate media for experimental comparison would next be selected, based on how closely presentation by each medium was expected to approximate the requirements established by the instructional events identified in step 1, above. Placing the

media-selection step second deviates from the current procedure of selecting the media to be evaluated before performing any detailed analyses of the subject matter to be presented by the media.

3. Decisions on how to prepare the total experimental materials would depend on whether the investigator wished to (a) evaluate the relative effectiveness of each of several media, or (b) determine the effectiveness of a multi-media package. Ideally, research under (b) would not be attempted until evidence from studies under (a) permitted the investigator to make appropriate media choices for a multi-media package.

In the first instance (type "a" research, above), experiments would be conducted to compare the effectiveness of media alternates identified in the media schedule (see Chapter II) for a given objective. Some experiments would compare alternate media for a single instructional event; other experiments might compare media over all instructional events for the particular objective of interest. A number of such experiments for a given objective (representing a given type of learning) could yield conclusions like the following: "For learning concepts which are formed by making discriminations among visual, nonverbal stimuli, Medium X worked best. Concepts of this type are represented by the following examples from several subject-matter areas: . . . "

It is suggested that research of this kind may result in fewer "no-difference" findings, for reasons presented earlier.

In the second instance (type "b" research, above), alternate multi-media packages would be compared. One reason for experimental work with multi-media packages, of course, is to evaluate the practical effectiveness of a particular package which was designed by use of the recommended type "a" research, or by the procedures outlined in Chapter II. For example, one might compare alternate strategies for the design of multi-media instruction, e.g., the strategy proposed in Chapter II as compared to some simpler strategy which might be developed. Probably both would be superior to the absence of any strategy for the employment of the various media.

A second reason for comparing the relative effectiveness of multi-media packages would be to determine which practical compromise works best, when it is not possible for practical or economical reasons to follow all the findings from type "a" research, without encountering awkwardness in changing from medium to medium. For example, when the media schedules are scanned for a whole sequence of objectives and it is apparent that the original analysis cannot be implemented in the form thought theoretically best, several bases may be seen for how to make a compromise package.

While this type of research appears less basic than does the type "a" research described above, a different kind of generalization conceivably could be reached thereby. For example, it might be found that "when it is difficult to present the ideal sequence of sounds, pictures, and printed words, and when the ratios of need for the three are about equal, it is more acceptable to make a package which deletes some of the sounds."

A third reason for this type of research might be to check the sequencing of instruction for deviations or options which might exist. Where it is shown by experimental results from such studies that sequence does not have to be rigid, one sequence may be easier to schedule than another with reference to planning how to integrate individual instruction with group instruction. For example, one sequence might permit certain students to work on a programmed instruction phase of the unit, while other students worked on a tape-recorded portion of the unit, with provision for occasionally bringing individuals and small groups together for filmed or televised presentations to large groups.

Expected benefits of the new research strategy. Assuming that standard requirements for good experimental design are met (Campbell and Stanley, 1963), media studies of the kind outlined above

should produce more useful and generalizable principles than have been produced by current media research. This is because reports of media research carried out under the proposed system would be able to define precisely the factors involved in the "instructional systems" being compared. These factors, to repeat, include media, learner, subject-matter, and situational characteristics which taken together form the basis for being able to determine the relative appropriateness of a given medium for a given instructional objective (in terms of satisfying learning conditions required by the task). When this sort of information is provided for the reader, he will be able more easily to estimate the relevance of that research for his particular situation (defined along the same dimensions).

Furthermore, the fund of evidence which would accumulate from this sort of systematic media research would, in Norberg's words, ". . . help build the foundations of a science of instructional technology," by explicitly identifying the variables and their interrelationships which are crucial to learning.

CHAPTER VI

Summary, Conclusions and Recommendations

Leslie J. Briggs

Summary

The work of this project has been directed toward the improvement of instruction through development of an analytical procedure for selection of instructional media. This procedure, applied as recommended, constitutes a basis for matching media with educational objectives.

In Chapter I the thesis was presented that educational specialists, rather than either commercial producers of educational materials or specialists in particular media, should select the media by which instruction will be presented. The selection should take place through an analysis of educational objectives; this analysis should be performed at the time of the original design of the curriculum. The resulting specifications for sequences of instruction in the selected media should guide the actual production of instructional material. Thus the educational personnel who are responsible for the conducting of the instruction would also become the determiners of the media in which instruction would be programmed. The selection of media would

take place before the materials are produced, not afterwards.

The basis for the analysis by which media are matched to objectives should involve the use of the most dependable and generalizable knowledge available concerning the conditions of instruction required for each type of learning represented in the educational objectives.

A review of classroom research in educational media revealed that the experiments reported were not designed to provide the kind of information required to develop the needed procedure for selecting effective media for instruction. The reasons for this are discussed in Chapters I and V. While classroom research often has provided the basis for deciding between alternate existing materials for particular courses, and has indicated ways to improve the programing and use of specific media in the classroom, these studies do not show how to assign media to objectives. However, use can be made of the results of analytic studies of specific variables in learning and of specific features provided by various media, when considering particular steps in the selection of media.

The kind of research which provides the most generalizable information for the purposes of this project has already been reviewed by Gagne (1965), who has also arranged the results from the research in terms of the external conditions of learning needed for each of the eight kinds of learning he has identified. This information

concerning types and conditions of learning is the most generally useful information available because it can be applied in the analysis of instructional requirements for any subject-matter area.

The procedure which was developed during this project for the analysis of educational objectives for the purpose of selection of media for instruction is described in Chapter II, and illustrated in Chapters III and IV. This method of analysis begins with identifying each educational objective (stated in behavioral terms) as to the type of learning it represents, in order to identify the general conditions of learning required. It is at this step that the general conditions of learning, as outlined by Gagne, may be identified. The next step, however, consists of identifying the exact instructional stimuli required for each specific objective in order to plan the instructional events which would implement the conditions of learning for that objective. This step, involving the translation of instructional events into the particular stimuli, is needed in order that the media for presentation of those stimuli may be chosen. Since these decisions must be made for each particular objective being considered, any empirical research on how to make these decisions would be specific to the objective, and hence might be labeled applied research. Even so, in making the particular selections of the stimuli and then the selection of the medium for a given objective, much use can be made

of the more analytic research findings which relate the effectiveness of single variables in learning, such as degree of prompting, to the type of learning involved.

Once the stimuli and media alternatives are listed for each instructional event needed for several objectives in a row, then the entire set of analyses is viewed in an overall fashion in order to utilize a given medium for some optimal period of time before changing to a different medium. This step cannot be done in any cookbook fashion; it requires consideration of a complex set of practical factors which, when viewed together, can result in a trade-off decision, or compromise solution -- compromise between (a) precision in supplying the stimuli as initially analyzed for each objective, and (b) practicality, convenience, cost, and ease of changing from one medium to another medium. Final "packaging" decisions are often made by a combination of rearrangement of the sequence in which instruction may be presented, and application of trade-off decisions.

Application of such a procedure, which employs basic knowledge of types and conditions of learning and analytical judgment in using results of research on single variables in each type of learning, should result in sizable improvements in the effectiveness of instruction. Since almost all educational courses involve several kinds of learning, and since many forms of stimuli are needed to provide the

specific instructional events for all objectives, it is predicted that most courses would require multiple media of instruction. It is an empirical matter, however, to determine the extent of improvement in learning which may be brought about by this type of analysis and the resulting packages of multi-media instruction.

Curricula designed in accordance with the recommended procedures could result in the packaging of instruction in relatively small units so that the child's particular program could be adjusted to his abilities and goals.

While it is felt that the steps in the total analysis are generally those needed for the purpose, several variations in the way that the steps may be taken have been illustrated in Chapters III and IV. The analyses presented in those chapters also tend to confirm the view that the analysis must be done for one objective at a time, even though the objectives as originally encountered can be grouped either by type of learning (behaviorally) or by subject matter (content areas). The optimum form for stating objectives, it was shown, consists of a statement of the behavior desired in reference to specific content stimuli.

Finally, the flexibility inherent in the statement of media options for each instructional event for the objective gives rise to the possible use of either (a) simple materials and objects for teacher-conducted, group instruction, (b) to the use of available automated equipment, or

(c) to the utilization of complex equipment yet to be designed.

The total procedure, then, results in the requirement for several media because a variety of types of stimuli are needed to fulfill all the requirements of the kinds of learning represented. Extensions of the analysis, if made to account more directly for individual-difference variables and situational variables, could conceivably become so complex as to acquire new data-handling procedures.

While the present procedure is fairly straightforward in terms of the steps listed, it does require complex judgments. The ability of several people to agree upon a specific analysis is yet to be tested. Also, even though the analysis is quite detailed and hence time-consuming, it appears well founded and deserving of empirical test, evaluation, and improvement.

Conclusions

1. The analysis as outlined in Chapter II was tried out for a set of behavioral objectives for a recently designed experimental curriculum in science instruction. It was found quite possible to illustrate and implement the steps outlined in Chapter II, for sample objectives representing various kinds of learning.

2. The analysis was also conducted, although for fewer objectives, for a more conventional curriculum in geography and geology, in which

the objectives were first stated in terms of content, rather than in behavioral terms. While it was shown in that analysis that grouping of objectives can be formed separately by content, then by type of terminal behavior, the final steps in the analysis require the pairing of a content item with a behavioral item. Such separate groupings, then, are not economical to make for the purposes of this analysis, but the groupings may be useful in the course of agreeing upon the nature of a curriculum and for communicating that information to other persons.

3. The merits of prior classroom research involving various media of instruction lie primarily in: (a) the choosing from among alternate media for particular sequences of instruction which are available; (b) the demonstration that multi-media instruction has consistently been found superior to single-medium instruction; and (c) the identification of specific features of media which will implement specific variables in learning conditions. Thus media research has resulted in improved programing and use of single media, each taken alone, although the findings helped little in the design of the procedure for choosing media as outlined in this report.

4. Some media research has been criticized on the basis of faults in methodology, design, and control, as well as for the failure to study the effects of particular media for well-defined types of learning

(see Chapters I and V). Much improvement is needed in future media research to gain either useful situation-specific findings or generalizable principles. The implication of the present report is that media research needs to be conducted for single experimental objectives representing various kinds of learning. Even so, the design of instruction, it appears, must rest upon good judgment in the specific applications of research findings as dictated by the requirements of stimulus conditions needed for the particular objective.

5. One kind of research found useful in stating the details of instructional events required was represented by laboratory investigations in which single variables in learning were analyzed for well-defined types of tasks. As to the design of the total procedure for conducting the analyses, the material of most direct benefit was the organization of research knowledge by type of learning as presented in the book by Gagne (1965).

Recommendations

First, as to the method of analysis presented in this report for selecting educational media, several types of follow-on work need to be accomplished. Some of the work needed is as follows:

1. Study of the extent of agreement among professional people in applying the various steps of the procedure to a particular set of

objectives.

2. A listing of examples, from a wide variety of subject-matter areas, of behavioral objectives representing the various kinds of learning. Such a list would help persons conducting the first step in the recommended procedure.

3. Empirical test, evaluation, and improvement of the procedure, by preparing at least two different courses (or course units) by the procedures outlined in this report, and comparing learning results with results from any other proposed method for the design of multi-media instruction.

4. Empirical comparison of the effectiveness of the above multi-media packages with the effectiveness of any single medium of instruction designed with equal care.

5. Continued search for general guidelines, or rules of thumb, which might aid practitioners in conducting the type of analysis here advocated.

6. Preparation of a "Media Taxonomy" which would list both commonly known and unusual, or potential, features, stimulus dimensions, and instructional functions which can be provided by various media.

7. Expansion of the system of analysis to account for individual-difference and situational variables.

8. Applied research to evaluate particular media options for specific objectives to validate judgments and to aid in the search for new generalizable insights.

Second, as to alternate approaches to procedures for matching media with objectives, other first efforts, like the effort represented in this report, deserve to be made. The present effort has of course grown out of certain basic viewpoints about learning and instruction, including the view that there are many kinds of learning, each requiring somewhat different conditions. Though the present writer is convinced of the tenability of this view, it is recognized that this view is not shared by everybody. It is, therefore, desirable that persons having alternate views attempt to develop alternate procedures which would make use of those views. The overall problem appears sufficiently important to education to justify several independent attempts to find the most effective and most practical procedure for choosing effective media of instruction.

Third, research to improve the usefulness of the various individual media should be continued. Such research is complementary to the matter of choice of media.

Fourth, further research is needed in particular matters which are related to the effectiveness with which the presently proposed method of analysis may be applied in practice. Some of these needs

include the following:

1. Studies of the interaction effects of individual characteristics of the learner, types of learning, kinds of media, and situational variables in the use of media.
2. Studies of the attitudes, abilities, and techniques of teachers who effectively employ media of instruction.
3. Study of ways to use instructional media to overcome subject-matter and pedagogical deficiencies in the training of teachers.
4. Study of the utilization of media in relation to the special problems of education: the retarded or underprivileged; the vocational trainee; the superior student.
5. Study of the capabilities of computers and new kinds of AV control and integrating mechanisms for the presentation of instruction; study of the capabilities of computers for making branching decisions for individualized instruction.
6. Study of methods for specifying media requirements in the form most helpful to the specialists who will develop the instruction in the various media.
7. Integration of new curriculum approaches with new instructional approaches.
8. Continued study of the programing techniques which are effective for each of the media.

9. Study of the role of the teacher in multi-media instruction.
10. Research on ways to introduce young children to special effects utilized in media: perceiving a picture of a horse in terms of "real size"; translating relative magnitudes in pictorial presentations (meters, centimeters) to "real dimensions"; perception of "freeze frames" as distinguished from motion portrayed by a film.
11. Analysis of the role of manipulation of real objects versus pictorial representation in concept formation by young children, in the continuing search for improving the effectiveness of visual media.
12. Analysis of factors in the relative effectiveness of personal experiences with objects and materials, as compared to watching live demonstrations or seeing filmed demonstrations.
13. Continued study of the kinds of concepts for which various sequences of stimulation are effective: visual, then verbal; verbal, then visual; simultaneous audiovisual, then verbal; etc.
14. Increased basic research in the "higher" forms of learning: concept formation; principle learning; problem solving.

Closing Note

This project was conducted on a work schedule covering only a period of six months. The budget was limited in accordance with the time schedule. The reason for this schedule was that this project was

conceived as providing only the opening phase of work on the problem to which the project was oriented. During this phase of work four activities were accomplished:

- (1) A selective critical review of the literature.
- (2) The development and description of the steps in a procedure of analysis by which media are selected in accordance with the specified objectives.
- (3) The first two sample analyses illustrating the recommended procedure were conducted for a few objectives from two elementary-school courses.
- (4) Recommendations were made for further work on the recommended method of analysis, and for needed related research.

In the judgment of the authors of this report, the beginning which has been made is sufficiently promising to warrant continued follow-on research to improve and sharpen the procedures for analysis of this important educational problem.

As mentioned earlier, the authors sought the most simple and practical method of analysis consistent with the major premises upon which the rationale of the work was based. They all wish a simpler method had been found. But unless such a method is forthcoming, they advocate the improvement, evaluation, and implementation of both the

technical and procedural recommendations set forth in Chapter I.

The effort to treat objectives in groups as one way to simplify did not turn out promising, for reasons discussed elsewhere in this report. The writers hope that this first contribution to an effective solution to the problem outlined in Chapter I will prove to be a sufficiently firm foundation upon which continued work can be based.

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